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LOBECTOMY AND PNEUMONECTOMY IN THE TREATMENT OF PULMONARY TUBERCULOSIS

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IN MAY, 1943, Churchill and Klopstock[1] reported the successful accomplishment of lobectomy in six cases of pulmonary tuberculosis. Three of these cases "provided orthodox indications for resection of the lesion by lobectomy. Three others presented the usual indications for thoracoplasty but lobectomy was performed by election." Because the indications for this procedure were by no means clearly established and because of the need for a carefully controlled experience upon which to formulate a policy with regard to the application of extirpative surgery in the treatment of pulmonary tuberculosis, it was decided to use the method in a series of suitable cases. Furthermore, the scope of application was extended to include cases which required a pneumonectomy. Until May, 1945, twenty-seven lobectomies, including the original six cases of Churchill and Klopstock, and thirty-six pneumonectomies had been performed. The present report does not include any cases where the operation was performed after May, 1945; this allows the lapse of at least one year as a minimal period of observation upon which to base a report.

It is interesting and significant in the light of our increasing knowledge of the disease that of the original six patients only four can be said to have done well three years later. One has died of widespread reactivation of the disease in the lower lobe on the side of the operation and in the opposite lung. Another is back in the sanatorium with a flare-up of disease in the ipsilateral middle and lower lobes, which was heralded by the development of hemoptysis. This knowledge should give us pause and has prompted a careful review of the entire series.

At the outset it should be understood that it is only after the expiration of several years that the end results of treatment in such a series become known.

From the Surgical Services of the Massachusetts General Hospital.

Read at the Twenty-sixth Annual Meeting of The American Association for Thoracic Surgery, Detroit, Mich., May 29, 30, and 31, 1946.

It has been striking to observe with what frequency patients subjected to lobectomy or pneumonectomy have made a completely uncomplicated recovery during the immediate postoperative period. The contrast between the comfortable and rapid recovery in these cases and the prolonged uncomfortable and sometimes stormy convalescence after a thoracoplasty favors extirpation. But what appear to be very encouraging results at first have many times turned out to be disappointing when appraised some months later. It is actually too soon to learn what the ultimate results will be in this series, but a one to three year follow-up review already serves to indicate to some extent what may be expected.

INDICATIONS

Lobectomy.—In certain cases the decision to perform a lobectomy was based upon the presence of a cavity in an unfavorable location for collapse therapy, such as in the middle or lower lobes. Two cases of tuberculoma were chosen because of the well-recognized difficulty of management in all such lesions. Stenosis of the major bronchus to a lobe, causing complications resulting from atelectasis and obstruction, provided the indication for lobectomy in two cases. In nine cases the choice was based upon the fact that the patient had a large rigid-walled cavity of a type which can rarely be completely closed by artificial pneumothorax or even by extensive thoracoplasty. The decision to perform a lobectomy in this group would doubtless be considered proper by many phthisiologists. But in the remaining eleven cases the choice of lobectomy over thoracoplasty was made in the hope that the former operation would provide a more comfortable and a more rapid method of handling the situation. In these cases, however, a thoracoplasty would ordinarily have been performed in anticipation of a good end result.

Pneumonectomy.—In the pneumonectomy group the indications were somewhat different. Of the thirty-six cases, eighteen were of the desperate-risk type. These were the patients with a destroyed, almost completely functionless, lung containing one or more large cavities. In all, the bilateral distribution of the disease was obvious. In all, the prognosis was considered to be practically hopeless if nothing were done. The remaining eighteen cases were divided among a group of other indications. Stenosis of the main bronchus with its attendant complications was the indication in six cases. The presence of a persistent unhealed cavity beneath a properly performed thoracoplasty was the reason for the choice of pneumonectomy in four cases. In two the preliminary diagnosis was carcinoma, but tuberculosis was ultimately demonstrated. In five instances the choice of pneumonectomy was made at operation in cases which were thought at first to be suitable for a lobectomy. The decision in these cases was based upon the fear of spread of infection in the lung or development of empyema which might result from cutting across tuberculous foci in cases of incomplete or absent fissures between the lobes.

GENERAL MANAGEMMENT OF THE CASES

Bronchoscopy was used freely as a diagnostic measure whenever bronchial disease was anticipated.

Some form of chemotherapy was used in the majority of the cases. Sulfa drugs, usually sulfadiazine administered orally or intravenously, were used in a large number. They were not used in the pleural cavity or locally around the stump of the bronchus. After it became available for civilian use, penicillin was used prophylactically. The use of sulfonamide or penicillin chemotherapeutic agents prophylactically was intended to minimize the development of secondary pyogenic infections. This is important especially in cases of large infected cavities.

Ether and oxygen anesthesia administered intratracheally was used.

The patient was placed on the side opposite that which was to be operated upon and a standard thoracotomy incision was used. In those cases where a rib resection was performed, a rib was chosen which would give access to the region where the greatest difficulty from adhesions might be anticipated. In the younger patients an intercostal incision was used. Silk technique was used throughout. The vessels of the hilum were ligated individually. The stump of the bronchus was closed with interrupted fine silk sutures placed over the end. No mattress sutures were used. The closed bronchial stump was always covered with pleura.[2] In the pneumonectomy group the phrenic nerve was crushed so that the resulting elevation of the diaphragm might help to obliterate the space in the pleural cavity.

In order to avoid introducing any factor which might make it difficult to evaluate extirpative surgery as a single method of treatment, it was decided not to perform a subsequent thoracoplasty in the majority of these cases. Two such operations were performed, however, in one case in the hope of relieving unexplained pain deep in the mid-thoracic region, and in the other to counteract excessive emphysema in the overexpanded remaining lung. The latter patient died as a result of this thoracoplasty.

FINDINGS AT OPERATION

It is striking to find with what frequency the hilar structures in cases of pulmonary tuberculosis are relatively free from evidences of active disease. It was only in cases of marked bronchial disease that any degree of difficulty was encountered. Lymphadenopathy is rarely encountered except for evidences in the form of calcification of an old infection. This fact is responsible for the ease with which excellent healing and a smooth early recovery were obtained in so many of the cases.

It is noticeable also that in the absence of complicating pyogenic organisms one can cut across a tuberculous bronchus or even carry out an extensive dissection and a pneumonectomy in the presence of a tuberculous pleuritis without any early evidence of a flare-up of the disease.

Experience with lobectomy and pneumonectomy for tuberculosis serves furthermore to demonstrate that there are always foci, sometimes many of them, which are imperfectly visualized in the preoperative roentgenograms of the chest. In performing a lobectomy it was usually possible to find quiescent foci of disease in the lobe of the lung which was not removed. These foci tend in some cases to become reactivated during the early or even late convalescence.

This was demonstrated by careful roentgen-ray studies in certain cases. This fact serves also to emphasize what happens in the opposite lung in cases where a pneumonectomy has been performed. These flare-ups of activity are almost certainly the result of reactivation of pre-existing foci of disease and should not in the majority of cases be regarded as new implantations of the infection.

RESULTS

Complications.—Patients with tuberculosis who are operated upon at the Massachusetts General Hospital are admitted from the sanatorium, operated upon, and cared for until they have recovered from the surgical procedure, and then returned to the sanatorium. Complications and deaths resulting directly from the operation and dealt with at the Massachusetts General Hospital are classified as early. Complications and deaths which occurred after the patient had recovered from the operation and was therefore back at the sanatorium are classified as late.

In Table I are listed the complications which arose both early and late after both lobectomy and pneumonectomy. Obviously the most frequent complication was a *flare-up of disease* in the remainder of the same lung or in the opposite lung after lobectomy and in the opposite side after pneumonectomy. It is apparent, in this series at least, that such a reactivation which is often spoken of as a spread of disease occurred most frequently as a late complication months or years after the operation. Thus, of thirteen such occurrences after lobectomy, eleven developed late; and of ten after pneumonectomy, seven were of late occurrence. In the entire series of sixty-three cases, five early activations of disease developed in the same or opposite side (7.9 per cent). Of these, two occurred after lobectomy. One of these ended fatally and in the other the process has cleared. Three developed in the opposite lung after pneumonectomy. In two of these the patients died subsequently and in the third the process has cleared (Tables II and III).

TABLE I. COMPLICATIONS FOLLOWING LOBECTOMY AND PNEUMONECTOMY FOR PULMONARY TUBERCULOSIS

	LOBECTOMY (27 CASES)		PNEUMONECTOMY (36 CASES)	
	EARLY	LATE	EARLY	LATE
Flare-up (reactivation)				
Same side	2	3	--	--
Opposite side	0	2	3	7
Both sides	0	6	--	--
Tuberculous empyema				
With bronchial fistula	0	0	1	0
Without bronchial fistula	1	0	0	2
Staphylococcal empyema	1	0	1	0
Pyogenic pneumonia and bacteriemia				
Streptococcal	0	0	2	0
(?) Organism, (?) pneumococcus	1	0	0	0
Psychosis	0	0	1	0
Insufficient aeration	1	0	1	0
Cardiac decompensation	0	0	0	1
Total	6	11	9	10

TABLE II. POSTPNEUMONECTOMY ACTIVATION OF OPPOSITE LUNG

	DIED	ILL	CLEARED
Early	2	0	1
Late	6	1	0

In regard to activity which developed late after operation, as shown in Tables II and III, in the pneumonectomy group six out of seven have died and one patient is ill at the present time; and of the eleven lobectomy cases, four patients have died and seven are alive but ill because of failure of the process to clear.

TABLE III. POSTLOBECTOMY ACTIVATION OF HOMOLATERAL OR CONTRALATERAL LUNGS

	DIED	ILL	CLEARED
Early			
Same side	1	0	0
Opposite side	0	0	0
Both sides	0	0	1
Late			
Same side	0	3	0
Opposite side	1	1	0
Both sides	3	3	0

Tuberculous empyema developed early in one case. This resulted from the development of an artificial fissure between the upper and middle lobes by cutting too close to, or actually into, a small active focus of disease. No fistula occurred in this case. No late cases have been observed in the lobectomy group. Among the pneumonectomy cases the necessity for cutting across active lymph node and bronchial disease resulted in a tuberculous empyema with a bronchial fistula in one case. This patient died. In two pneumonectomy cases tuberculous empyema developed a number of months after the patient had made an apparently uneventful recovery. In neither was there a bronchial fistula.

Staphylococcus empyema developed once in a lobectomy case and once after a pneumonectomy. Both cases were observed before penicillin was available for civilian use. In both cases rib resection followed by thoracoplasty to help close the cavity brought the condition under control.

Pyogenic pneumonia and bacteriemia occurred in one lobectomy case and two pneumonectomy cases. All three patients died in spite of sulfonamide chemotherapy.

A *postoperative psychosis* developed in one patient.

Insufficient aeration occurred in two cases. Both patients died.

Cardiac decompensation contributed to the death of one patient who had made a reasonably good recovery after a pneumonectomy. She was known to have mitral stenosis, but was operated upon because of the hopelessness of the case.

END RESULTS TO DATE

Lobectomy Group.—The results of lobectomy in twenty-seven cases are summarized in Table IV. There were two postoperative deaths (7.4 per cent).

Twenty-five patients survived the procedure, but five of these died subsequently of the disease. Of the twenty patients still alive, seven show more or less evidence of activity at the present time, all of them with a positive sputum. All but one of these seven patients are under treatment in a sanatorium at the present time. The remaining thirteen patients are apparently well with a negative sputum.

TABLE IV. RESULTS OF LOBECTOMY FOR PULMONARY TUBERCULOSIS

RESULTS		NUMBER
Postoperative deaths		2 (7.4%)
Survivors		25
Died of the disease	5	
Alive with disease (sputum +)	7	
Apparently well (sputum -)	13	

Of the original twenty-seven patients who were subjected to lobectomy, seven (25.9 per cent) are dead. The causes of death, both early and late, are shown in Table V. Of the two operative deaths, one was the result of a pneumococcus pneumonia which did not respond to sulfadiazine. Penicillin was not available for administration at that time. In the other patient the exact cause of death was not determined and an autopsy was not permitted.

TABLE V. CAUSES OF DEATH FOLLOWING LOBECTOMY FOR PULMONARY TUBERCULOSIS*

DEATHS		NUMBER OF CASES
Postoperative		2
Pneumonia	1	
Cause undetermined	1	
Subsequent		5
Disease in remainder and opposite lung	4	
Tuberculous empyema + disease in other lung	1	

*Of the twenty-seven original patients, seven are dead (25.9 per cent).

As will be seen, all five patients who died subsequently after making a satisfactory early recovery suffered from reactivation and spread of the disease. These were patients who did not have sufficient resistance to the disease and were unable to overcome the virulence of the infection even though they had been relieved of a portion of the load by lobectomy. They died of the disease in spite of the treatment.

The present status of the twenty patients who survived is illustrated in Table VI. Six of these are now afflicted with a flare-up of disease in the remainder of the same lung or in the other side or both. All have a positive sputum. In one case a prompt flare-up of disease in the lower lobe occurred after an upper and middle lobectomy. This diseased lower lobe was removed one month after the original lobectomy and the patient, now classified as a pneumonectomy case, is apparently well. Of the thirteen patients (48 per cent of the original number) who are apparently well, eleven are able to work and five of these are actually working. Two are still not considered to be sufficiently recovered to allow them to resume their work.

TABLE VI. STATUS OF PATIENTS WHO SURVIVED*

PRESENT CONDITION	NUMBER	SPUTUM POSITIVE	SPUTUM NEGATIVE
With disease	7	6	0
Flare-up same lung	4	4	0
Flare-up same lung (lobectomy)	1	0	0
Flare-up same lung + other side	2	2	0
Apparently well	13	0	13
Able to work	11	0	11
Actually working	5	0	5
In sanatorium or at home and not working	2	0	2

*Of the twenty-seven original patients, twenty are alive (74.0 per cent).

From the standpoint of evaluation of future cases, Table VII is interesting. It shows the results of lobectomy in relation to the indication for operation. As might be anticipated, the eleven patients in whom good results would have been expected if subjected to thoracoplasty had the best record after lobectomy. None of these patients has died, although four show evidence of activity of the disease, at the present time. It is not surprising, likewise, to find that of the nine patients who had large cavities unsuitable for collapse therapy, only three can be classified as apparently well. Five of this group are dead and one is alive with a cavity in the contralateral lung. Of the remaining indications, bronchostenosis, tuberculoma, and unfavorable location of the cavity in the middle or lower lobe, the numbers of cases are too few to suggest any correlation between the results and the indication for the operation.

TABLE VII. RESULT OF LOBECTOMY IN RELATION TO THE INDICATION FOR OPERATION

INDICATION	NUMBER	DIED POST-OPERATIVELY	DIED LATER	ILL	WELL
Elective (suitable for thoracoplasty)	11	0	0	4	7
Large tension cavity	9	1	4	1	3
Bronchostenosis	2	0	1	1	0
Tuberculoma	2	0	0	1	1
Lower lobe	2	1	0	0	1
Middle lobe	1	0	0	0	1
Total	27	2	5	7	13

Pneumonectomy Group.—The results of pneumonectomy in thirty-six cases are summarized in Table VIII. There were seven operative deaths (19.4 per cent). Of the twenty-nine patients who survived, seven died later of reactivation and progression of the disease. Twenty-two patients are alive at the present

TABLE VIII. RESULTS OF PNEUMONECTOMY FOR PULMONARY TUBERCULOSIS (36 CASES)

RESULTS		NUMBER
Postoperative deaths		7 (19.4%)
Survivors		29
Died of the disease	7	
Alive with disease (sputum +)	5	
Apparently well	17 (47.2%)	
Sputum −	16	
Sputum +	1	

time. Five show evidence of activity of the disease in the remaining lung, all with a positive sputum. Of the seventeen who are apparently well, one has a positive sputum.

Fourteen (38.9 per cent) of the original thirty-six patients who were treated by the performance of a pneumonectomy have succumbed. In Table IX are given the causes of death. One-half of the deaths were operative. Two of these patients died of streptococcal bacteriemia. In one of these there was, in addition, a hemolytic streptococcus bronchopneumonia in the remaining lung. This patient had a large cavity from which streptococci were cultured. Sulfadiazine failed to overcome the infection. The origin of the infection in the other case was undetermined. A massive flare-up of tuberculosis in the opposite lung accounted for two other operative deaths. In two cases the cause of death was not discovered. One of these patients struggled out of bed and was found lying dead on the floor of her room. She had been mildly psychotic postoperatively. One other patient died of an overwhelming tuberculous empyema resulting from breaking into a mass of caseous lymph nodes around a markedly stenosed, diseased bronchus.

TABLE IX. CAUSES OF DEATH FOLLOWING PNEUMONECTOMY FOR PULMONARY TUBERCULOSIS*

DEATHS		NUMBER OF CASES
Postoperative		7
Streptococcus septicemia	2	
Massive spread in other lung	2	
Cause undetermined	2	
Tuberculous empyema	1	
Subsequent		7
Disease in other lung	5	
Hemorrhage in other lung	1	
Postpneumonectomy thoracoplasty	1	

*Of the thirty-six original patients fourteen are dead (38.9 per cent).

Of the seven patients who died late after making an apparently satisfactory early recovery following pneumonectomy, six died of disease in the remaining lung. One patient died as a result of a thoracoplasty on the side operated upon, which was intended to overcome a very pronounced shift of the mediastinum to that side with its resulting compensatory emphysema of the remaining lung.

TABLE X. STATUS OF PATIENTS WHO SURVIVED*

PRESENT CONDITION	NUMBER	SPUTUM POSITIVE	SPUTUM NEGATIVE
With disease	5	5	0
Late empyema	3	3	0
Disease in opposite lung	2	2	0
Apparently well	17 (47.2%)	1	16
Able to work	13	0	13
Actually working	11	0	11
In sanatorium or at home but not working	4	1	3

*Of the thirty-six original patients twenty-two are alive (61.1 per cent).

Twenty-two (61.1 per cent) of the original thirty-six patients on whom a pneumonectomy was performed are still alive. Their status is shown in Table X. Five of these patients are afflicted with activity of the disease, three of them with late tuberculous empyema, and two with reactivation of foci of disease in the opposite lung. Seventeen patients are apparently well (47.2 per cent). Thirteen of these are able to work and eleven are actually working. Four are still under treatment. One of these has a persistently positive sputum.

In Table XI are shown the results of pneumonectomy in relation to the indication for operation. As was the case in the lobectomy group, the poorest results were obtained in the cases with large cavities and destroyed lung. There were eighteen of this type. Ten patients are dead, four as an immediate result of operation and six subsequently. Five are ill with either empyema (three cases) or active disease in the other side (two cases). Only three of the eighteen can be classified as apparently well and one of these still has a positive sputum.

TABLE XI. RESULT OF PNEUMONECTOMY IN RELATION TO THE INDICATION FOR OPERATION

INDICATION	NUMBER	DIED POST-OPERATIVELY	DIED LATER	ILL	WELL
Destroyed lung (large cavities)	18	4	6	5	3
Bronchostenosis	6	1	0	0	5
Technical reasons	5	1	0	0	4
Thoracoplasty failure	4	1	0	0	3
Wrong diagnosis (preoperative diagnosis, carcinoma)	2	0	0	0	2
Tuberculosis superimposed on chronic bronchiectasis	1	0	1	0	0
Total	36	7	7	5	17

It is of interest that of the remaining eighteen patients all but four are apparently well. Four of this group died, three postoperatively and one subsequently. The latter patient actually had such marked evidence of the disease in the lung removed as to be properly included in the group with destroyed lungs. Of the six patients who were operated upon because of bronchostenosis, one died and five are apparently well. Of the four patients on whom a pneumonectomy was performed because of the persistence of cavities after an adequate thoracoplasty, one died and three are apparently well. Both of those who were operated upon with a preoperative diagnosis of carcinoma and who were later found to have tuberculosis are well.

DISCUSSION

Experience with lobectomy and pneumonectomy in sixty-three cases of pulmonary tuberculosis serves to re-emphasize certain fundamental facts concerning the disease. The frequent widespread dissemination of the disease throughout the lungs in the early phases of its development is striking. In almost all cases, by careful study of the early roentgenograms of the chest, the disease is found to be bilateral and often widely spread throughout all lobes of both lungs. Characteristically only a few of these foci develop into serious lesions, but at operation they can always be identified as small, yellowish, firm nodules which can be seen if near the surface and palpated if deep in the lung parenchyma. In

many cases where apparently new foci of activity in the remaining lobes or in the opposite lung develop, one can demonstrate that these areas were present in the early roentgenograms as small, almost imperceptible, often overlooked shadows, the significance of which has been learned by operating in many such cases. These areas are responsible for the so-called "postoperative spread of the disease," which is in reality frequently a reactivation of pre-existing small foci. It is this observation which makes it so important to study all of the early roentgenograms before deciding to perform a lobectomy or pneumonectomy in any given case.

It is obvious, therefore, that pulmonary tuberculosis does not lend itself to surgical extirpation in the sense that the entire diseased area can be removed. At best the surgeon can expect merely to eradicate the largest or most active focus of infection, but the patient's immunologic forces must be sufficient to overcome and hold in check the remainder.

Another fact regarding tuberculosis which is emphasized by a study of these cases is the importance of the immunologic balance between the resistance of the host and the virulence of the invading organism. Without a certain degree of natural resistance, no surgical procedure can be expected to succeed in the treatment of patients afflicted with the disease. Unfortunately, no entirely satisfactory method exists whereby this factor can be assessed. Often in the apparently most favorable cases the result is disappointing and conversely sometimes when an unfavorable result may be expected, a surprisingly good one is obtained. This well-known observation need not be illustrated by citing actual cases, but many examples occurred in this series.

With regard to the relation between the results obtained and the indications for operation, several observations are of interest. In both the lobectomy and the pneumonectomy groups, by far the greatest number of failures occurred in the cases of large cavity with marked lung destruction. This type of disease accounted for twenty-one cases of death or activation of disease in the remaining lung tissue. This is actually one-third of the entire group of sixty-three cases and 77.7 per cent of the large cavity group itself. It is well known that these cases do not respond well to any form of treatment thus far devised and extirpation is no exception. The mere fact that a patient develops one or more large cavities in the lung is evidence that his resistance to the disease is ineffectual. If one is anxious, therefore, to avoid a high mortality rate and a high incidence of reactivation, this group should not be subjected to extirpative surgery. Such patients usually die of the disease no matter what form of therapy is adopted.

Furthermore, on the basis of the patients included in this series, one cannot say that those whose disease was considered suitable for thoracoplasty did better in the long run, as a group, than they would have if a thoracoplasty had been chosen. Those who have remained well are of course less disfigured, no doubt more comfortable, and happier than they would have been after thoracoplasty. At least one-third of them have suffered a flare-up of activity following the surgical procedure.

By far the best results in this series were obtained in the cases of bronchostenosis requiring lobectomy or pneumonectomy because of irreparable damage to the lung distal to the level of obstruction and in the cases of thoracoplasty failure with persistent cavities.

CONCLUSIONS

Lobectomy and pneumonectomy in pulmonary tuberculosis can be performed with a degree of safety which makes it proper to consider their use in the treatment of certain suitable cases.

There are no absolute indications or contraindications which can be applied by rule in the use of these operations. In general, the best results in this series followed pneumonectomy in cases of bronchostenosis and thoracoplasty failure and lobectomy in those patients who might otherwise have been treated by thoracoplasty.

Extirpative surgery has failed to solve the problem of management of the cases with enormous cavities which are of the type which do not respond to collapse therapy.

There is no evidence which can be deduced from this series that, excepting in certain individual cases, lobectomy is superior to thoracoplasty so far as end results are concerned.

Because of the practical impossibility of eradicating the entire disease in the majority of cases by extirpation, the most important single factor in bringing about a successful result of treatment is the resistance of the patient to the disease.

Because pulmonary tuberculosis is not primarily a surgical disease, the hope for future progress in its management and cure lies in the possibility that some medicament may be developed which will overcome the invading organism and thus prevent the development of the well-known manifestations of the disease by eliminating their source.

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(*See discussion on page* 413.)

PULMONARY RESECTION IN THE TREATMENT OF TUBERCULOSIS

Present-Day Technique and Results

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THERE are complicated forms of pulmonary tuberculosis with fatal potentialities which may be managed successfully by resection. The combined efforts of all entrusted with the care of the tuberculous sick are required if resection is to be employed to the best advantage. Physicians can do much to recognize the inadequacy of bed rest alone and the failure of collapse therapy in individual cases. They must also appraise, fairly, the risk of the disease without resection. Thoracic surgeons are obligated to perfect the technique of resection in the interest of safety, maximum rehabilitation, and permanence of control.

Success in the management of other potentially fatal lung diseases, that is, cancer, bronchiectasis, and chronic pulmonary abscess, has done much to stimulate work in the field of tuberculosis. Progress is being made in all of these fields.

Two years ago, two of us[1, 2] made a preliminary survey of patients treated by resection. Further experience has led to certain changes in the selection of cases, in the plan of resection, and in general technical management.

This report will deal with the present-day operative procedure and risk as to postoperative complications and mortality. The present status of a consecutive series of 192 patients upon whom 200 resections were performed between 1934 and April, 1946, will be given.† Late complications will not be considered in detail. A follow-up report on all patients treated two to twelve years ago will be presented before the American Trudeau Society in June of this year.

TECHNICAL CONSIDERATION, PRE- AND POSTOPERATIVE CARE

Face-Down Position.—Most thoracic surgeons use the lateral position for pulmonary resection. This conventional side position has two distinct disadvantages, the first of which applies particularly to tuberculous lungs: (1) The diseased side is directly over the sound side. Gravity drainage of secretion and debris from the bad to the good lung is favored (Fig. 1). (2) Excursions of the thoracic cage and diaphragm on the sound side are impaired by the weight of the body.

In an attempt to reverse the relative position of the two lungs during operative manipulation, we now suspend the patient, face down and chest turned, so that the sound lung is uppermost (see Fig. 2, top and middle).

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†Since this paper was submitted for publication, twenty-five additional resections have been performed without immediate or late mortality.

This new reverse position has proved to be advantageous from several points of view:

1. Operative contralateral spread of disease has been reduced from 19 to 10 per cent.
2. The possible range of respiratory excursion is greater, and patients adjust themselves better to open pneumothorax.
3. The amplitude of mediastinal swing, or displacement, is greatly reduced.
4. The use of intrabronchial positive pressure can be eliminated in most cases.

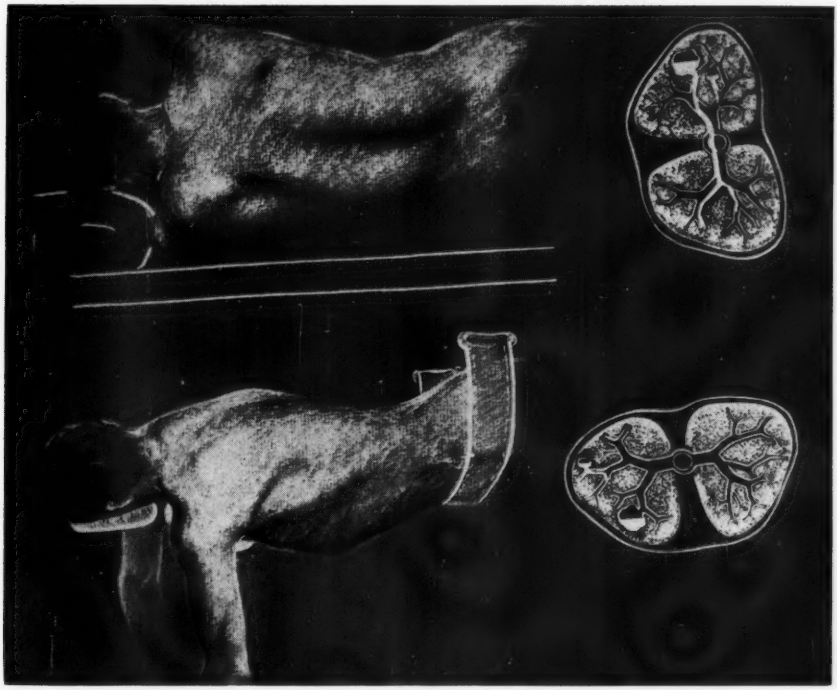


Fig. 1.—Drawing showing conventional side position and our position for bronchial drainage. Diagram illustrates the relationship of bronchi and secretions in the two positions.

5. Exposure of posterior aspect of the hilum is facilitated. When pleural symphysis is present (cases of pneumonectomy), preliminary ligation of the bronchus can be accomplished with minimal dissection and lung manipulation.
6. The weight of the lung itself allows it to fall forward, eliminating the necessity of holding up the lung or the use of any traction during dissection. In most cases the complete hilar dissection can be done by working entirely from behind.

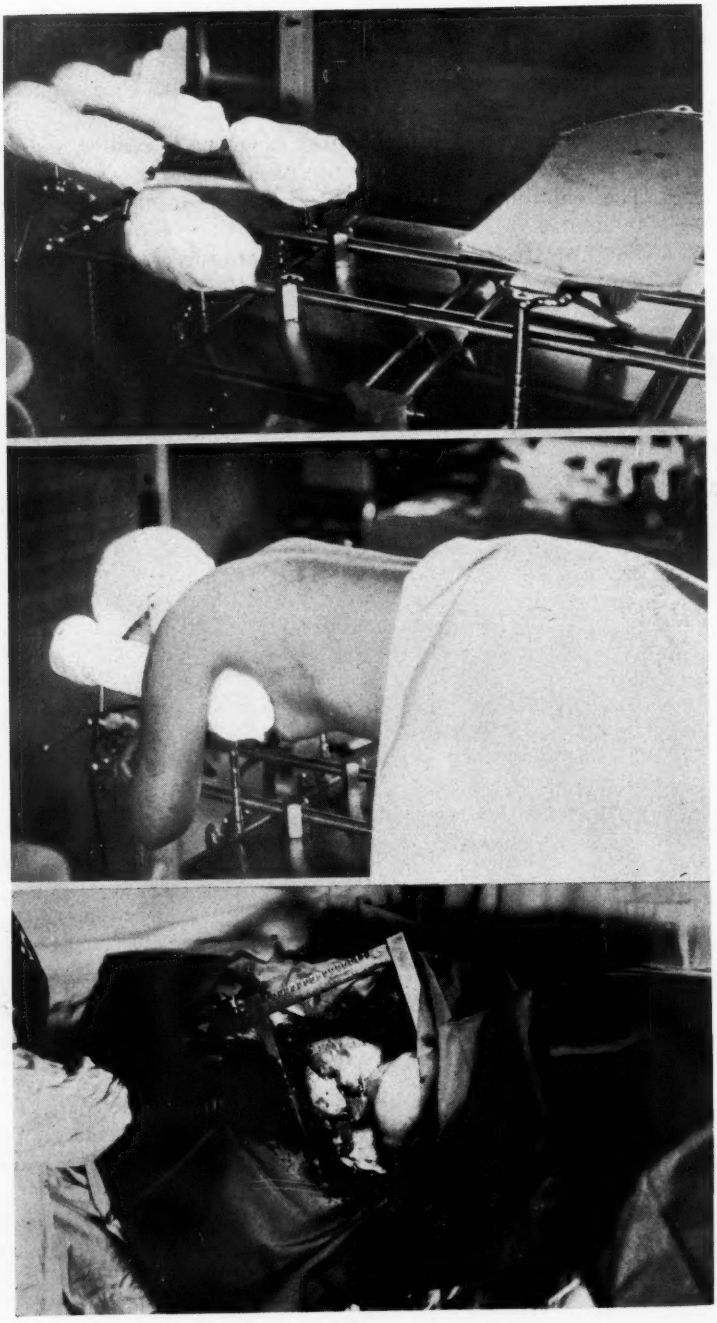


Fig. 2. (*For legend see facing page.*)

7. Cardiac irregularities, bradycardia, or cardiac standstill have been practically eliminated as complications. This may be due to avoidance of hilar traction during dissection.

Anesthesia.—The conventional method of administering anesthesia for resection of the lung has been a closed system with positive pressure and intratracheal-tube method. Many anesthetic agents have been used—cyclopropane, ether, nitrous oxide, or ethylene. It has been necessary for the anesthetist to carry a fairly deep plane of anesthesia in order to abolish the cough reflex which is overstimulated with the intratracheal tube in situ. The maintenance of a patent airway and the removal of secretions has presented the anesthetist with a difficult task. Repeated intratracheal aspiration throws the patient into bronchospasm, and control over the anesthesia is momentarily lost. Degrees of anoxia result and, not infrequently, disturbing vagovagal reflexes follow. Prolonged anesthesia over two, three, or four hours leads to tissue anoxia and favors shock. Deep anesthesia relaxes bronchial musculature and favors intrabronchial flow of secretions. The state of semiconsciousness with depressed cough reflex following prolonged periods of general anesthesia favors stagnation of secretions in the bronchial system.

Not being satisfied with the best general anesthesia that the professional physician-anesthetist could provide, we developed a method of paravertebral block anesthesia and intratracheal intubation after topical application. This method has the following advantages:

1. A better control of intrabronchial secretions can be obtained.
   (a) Retained secretions in the abnormal lung are not released by bronchial relaxation.
   (b) Aspirations do not disturb the plane of anesthesia or result in periods of anoxia.
   (c) The cough reflex is present throughout the operation and is effective at the conclusion of the operation.
2. The anesthetic agent is less toxic. This is an important consideration in long operations.
3. The immediate postoperative condition of the patient is better and nursing care is simplified. Nausea and vomiting rarely occur. The oral intake of fluid and nourishment can be started sooner.

Preparation of Patient and Novocain Injection.—The average patient is given the following preoperative medications: 3 gr. of nembutal (Gm. 0.20)

Fig. 2.—*Top* showing support for face-down position. The support consists of three parts: head rest, shoulder braces, and saddle for pelvic girdle. The head rest is horseshoe-shaped and cushioned with rubber. It allows exposure of the face. The mechanism of the head rest can be adjusted to any position or angle. The cushioned shoulder braces are two in number and are arranged so that they can be raised or lowered and moved from side to side independently. The pelvic girdle support is a heavy canvas saddle which is attached to the operating table. It is movable and can be raised to any desired level.

Middle showing the patient in the face-down position. The head, face down, is supported by a padded face ring. Both clavicles rest upon the shoulder braces. The shoulder and pelvic saddle support on the affected side are in a lower position than the opposite side. The operating table top can be tilted laterally to increase dependency of the affected side. The head end of the table may be adjusted to obtain any desired inclination of the head and chest. The chest and upper abdomen are free of supports.

Bottom showing exposure of the chest. This photograph illustrates the wide exposure obtained in the face-down position.

two hours before operation, and morphine, gr. ⅙ (Gm. 0.01), and scopolamine, gr. 1/150 (Gm. .0004), one hour preoperatively. Novocain, 0.4 per cent, is made up in the amount of 400 c.c., containing ten minims of adrenalin. Two-thirds of this amount is used for local infiltration in the skin and muscles in the line of the incision. Approximately 15 c.c. of the same dilute novocain solution are injected into each intercostal area just lateral to the vertebral bodies, the fourth to ninth dorsal vertebrae inclusive. The subscapular space is also injected with approximately 30 c.c.

The larynx is then prepared by spray and topical application of 10 per cent cocaine, as is done for bronchoscopy. An intratracheal tube with an inflatable cuff is introduced. The mouth is packed with gauze, and the tube secured in place. A cannula is tied in the long saphenous vein, just above the ankle, for continuous venoclysis. Citrated blood from the blood bank is started simultaneously with the incision and is regulated to replace the estimated loss of blood, cubic centimeter for cubic centimeter as it takes place. The amount of blood given varies with the estimated blood loss. The average patient in whom resection has been done receives between 1,000 and 1,500 c.c.

Exposure.—The incision is carried out posterolaterally. It begins at the level of the fourth rib, between the scapula and the spine, and extends downward and forward, two inches below the tip of the scapula, to the anterior axillary line. A long incision is necessary if proper exposure is to be obtained. Adequate space facilitates a thorough exploration without traumatizing pulmonary tissue or necessitating undue traction on the lung or hilar structures (see Fig. 2, bottom).

In pneumonectomy cases it is important to make provision for an airtight closure of the thoracic cage, as control of intrapleural pressure is essential. We have found it easier to close the chest in an airtight manner if a full rib length has been resected, for the muscle bundles and periosteum provide a structure that may be sutured. In pneumonectomy cases, therefore, we almost routinely resect the sixth rib and remove the full length of it. Small paravertebral segments of the fifth and seventh ribs are then resected. The intervening muscle bundles are divided and the vessels ligated. The intercostal nerves are dissected free and divided.

After lobectomy, an airtight closure of the thoracic cage is not mandatory, for rapid escape of air and fluid from the pleural space into the subscapular space aids in re-expansion of the remaining lobes or segments and, therefore, may be desirable. Upon theoretical grounds, it might be argued that escape of fluid from the pleural space would disseminate infection. We have never seen this in lobectomy cases. The exposure of the lung is obtained by removing two short rib segments, posteriorly and extending the incision in the intercostal space for the full distance of the space.

Technical Matters Concerning Dissection.—There are several principles of technique that have been helpful to us in dissection of the lung:

1. The division of pleural adhesions is done by sharp dissection to avoid injury to lung parenchyma.

2. The separation of the lung from the chest wall is started in areas where the adhesions are thinnest. In most patients, this is found anteriorly, and the

dissection is started there. Even in cases where the lungs are virtually frozen in the chest, the dissection can be accomplished cleanly and with little or no loss of blood. It is helpful to find the soft areas of pleural symphysis first and then, after encirclement of the dense adhesions, complete their division.

3. The rib spreader is placed only after the lateral aspect of the lung has been liberated from the chest wall.

4. Lung clamps, or forceps, are avoided, for they traumatize the lung, increase likelihood of contamination, and encourage assistants to make undue traction on the lung root.

5. Whenever possible, pleural adhesions are divided in preference to stripping the endothoracic fascia. The interpleural plane is less vascular. If, however, the covering over a cavity is thin, it is often wise to strip the endothoracic fascia in that area.

6. Novocain is injected into the vagus nerve early in the course of the dissection, as reflexes (vagovagal) which slow the heart are then blocked. This is done as the first step in treatment of the hilum.

7. The main bronchus is ligated with a temporary, encircling ligature before extensive mobilization and manipulation of the lung take place. Fortunately, in tuberculous subjects the hilar structures usually are not bound down by inflammatory changes. In the performance of pneumonectomy, the main bronchus can be reached with minimal manipulation of the lung itself. The sooner the bad lung is divorced from the good lung, the less possibility of bronchogenic dissemination of disease.

In removing a single lobe or segment, it is easier to treat pulmonary arterial branches prior to dissecting the segmental bronchi. In lower lobe resections, the bronchus can be readily ligated immediately after the artery is divided and before extensive mobilization of the lung is done.

8. Great care is taken to prevent contamination by tuberculous secretions. Earlier in our experience, we took liberties in lung dissection in the interests of speed which resulted in tearing of lung parenchyma or the opening of a cavity. The incidence of empyema is related to the incidence of such contamination.

At times we have considered it wise to accept contamination and deliberately evacuate the contents of a giant cavity prior to dissection of the lung. If this is done, the adjacent tissues are protected with towels, the cavity sutured, and instruments and materials which have been used are discarded. The pleural cavity is then thoroughly washed with saline solution before proceeding with the handling of new tissue.

Some Principles in Treatment of the Vessels.—We consider it important to have three sides of any vessel exposed prior to final dissection. This is a safety step, for the vessels can then be compressed with thumb and forefinger in case of tearing during the course of the dissection. It is advisable to divide branches of the vagus and widely separate the mediastinum pleura before dissecting the main pulmonary artery or the branches to the upper lobe. In pneumonectomy, distal sutures can be placed around the branches. This provides a greater space between the proximal and distal ligatures. It has been our practice always to transfix two proximal ligatures after a preliminary mass ligature has been secured.

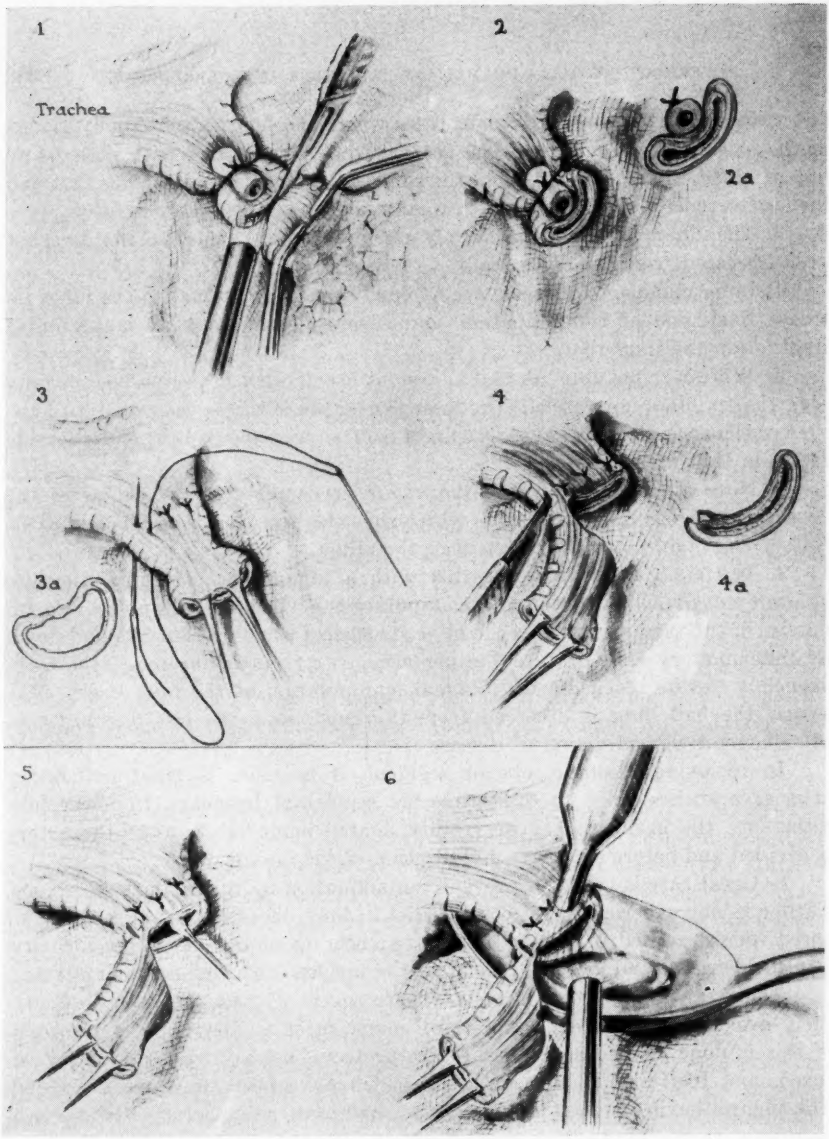
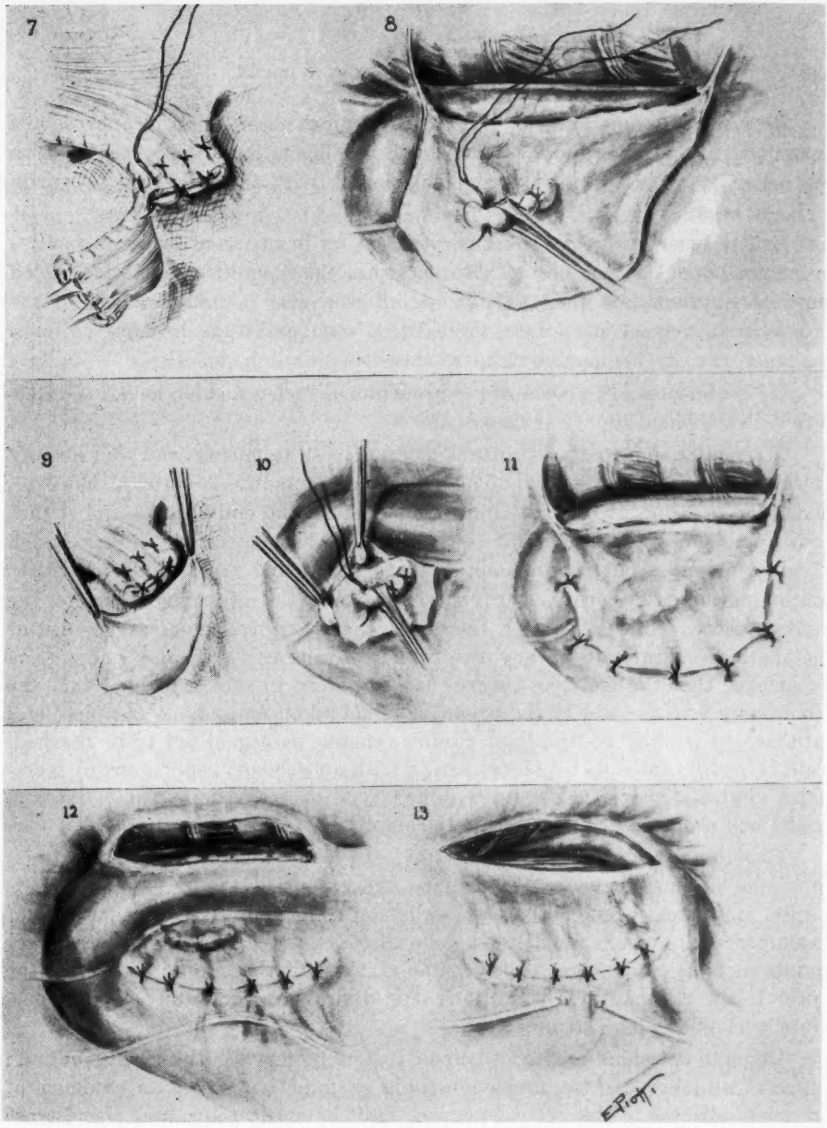


Fig. 3.—Illustrations showing closure of bronchus. Drawings *1* and *4* show preliminary bronchial division and reamputation. The bronchus is severed first between the temporary proximal ligature and two right-angle clamps are applied on the distal portion of the bronchus. Prior to the division of the bronchus, the pleural cavity and mediastinal surface are completely protected with gauze pads and towels. Continuous aspiration on the exposed bronchial lumen is carried out as the bronchus is being divided (Drawing *1*). Invagination of the membranous portion of the bronchus with rubber tube in place is shown.

The cut end of the bronchus is clamped with two Allis forceps. The encircling ligature and rubber tube have been removed. Three mattress sutures are placed close to the carina in a diagonal direction, either through or between the cartilaginous rings. A cross section of open bronchus is shown in Drawing *3a*. An attempt is made to include the bronchial artery in the mattress suture close to the inferior edge of the bronchus (Drawing *3*). These mattress sutures act as a first line of defense against the strain on the end sutures of intrabronchial pressure which is increased with cough. The mattress sutures flatten the bronchial stump and also decrease the size of the intrabronchial pouch. The mattress sutures so placed do not deprive the end of the bronchus of its blood supply.

The bronchus is now reamputated 3 mm. distal to the mattress suture line. Complete severance is not carried out immediately as the uncut edge is used for traction (Drawing *4*). The most distal cartilage is then cut with a small knife in order to break the ring and obtain a better surface coaptation (Drawing *4a*).



Drawings *5* to *8* show final treatment of reamputated bronchial stump. The bronchial mucosa distal to the mattress sutures is cauterized with a bead of sodium hydroxide, and this is neutralized with 6 per cent acetic acid (Drawing *5*). Cauterization of the mucosa reduces the bacterial content and also invites better cicatrization.

The bronchial stump is washed with saline (Drawing *6*). Through-and-through end sutures are now put in place (Drawing 7). Three or four of these end sutures will usually suffice to secure the edges of the bronchus. The remaining bronchial edge used for traction is then divided. A flap of endothoracic fascia and pleura is dissected from the costovertebral portion of the chest wall. It is developed so that its length is sufficient to permit the bronchial stump, which has retracted well within it, to cover the mediastinum loosely (Drawing *8*). The flap is then sutured to the bronchial stump with three additional end sutures.

Drawings *9* to *13* show variations in bronchial stump reamputation. A free fascial or pleural graft may be removed from any area and sutured to the bronchial stump with three or four end sutures (Drawings *9* and *10*). While suturing the free graft the vagus nerve is retracted (Drawing *10*). The stump then retracts into the mediastinal tissue, carrying with it the free graft. The mediastinal rent is covered either by a pleural flap dissected from the costovertebral portion of the chest wall or by suturing both edges of the mediastinal pleura (Drawing *11*). On occasions when the mediastinal rent is too wide it may be necessary to undermine the pleura over the aorta or esophagus in order to get a better approximation of the edges (Drawing *12*). On the right, the phrenic nerve is transected (Drawing *13*). This gives further relaxation of the mediastinal pleura used to cover the stump.

Bronchial Closure (Fig. 3, 1 to 13).—Clinical observation, bronchoscopic examination, and the study of pathologic specimens have impressed us with the necessity of carrying out bronchial closure with the following two principles in mind:

1. The bronchus is divided near the carina in order to leave as small a bronchial pouch as possible. This diminishes the amount of secretion which may later accumulate there. High amputation also permits the end of the bronchus to retract deep into the mediastinum and thus be covered with the loose, areolar, connective tissue of these surrounding structures.

2. The sutures are placed in the bronchus in such a fashion as not to interfere with the blood supply of the stump.

We realize that mattress sutures bring mucosa to mucosa and that healing at that level does not occur. The placement of mattress sutures, however, does give one line of defense against a strain on the end sutures and it permits a meticulous treatment of the end of the bronchus after the exclusion of air currents from the remaining tracheobronchial tree. This minimizes contamination and permits the cauterization of the bronchus down to the mattress suture line. We feel, therefore, that the advantages of the use of the mattress suture offset any theoretical objections. We also know from experience that the mattress sutures can be placed in such a manner that the blood supply to the end of the bronchus is not compromised. A complete and satisfactory method of bronchial closure remains as a goal yet to be reached. Failure results in bronchopleural fistula with subsequent aspirations of secretions, contralateral spread, and a mixed type of empyema. These developments will prove fatal unless treated promptly and effectively.

Planning the Extent of the Resection.—In most cases serial x-ray and bronchoscopic findings have pre-determined the extent of the resection; for example, main-stem bronchial disease calls for a pneumonectomy regardless of exploratory findings. Also, lower lobe disease on the right side with lower endobronchial involvement calls for the removal of the middle as well as the lower lobes. Under these conditions it is desirable to amputate the intermediate bronchus as high as possible.

Difficult decisions are forced upon the surgeon when the roentgenogram suggests unilobar disease, and endoscopic examination shows no evidence of bronchial disease. The roentgenogram may be misleading, and the disease may be more extensive than anticipated. Contraction of the upper lobe, with marked displacement of the lower, may have occurred. Careful palpation of the supposedly healthy segments should be carried out. Careful appraisal of nodularity in adjacent lobes should be made. Unless they are calcified, or of known stability, a more extensive resection than originally planned is usually the best. The superior segment of the lower lobe may be involved. If the disease is well localized and the basal segments normal to palpation, this segment may be removed with the upper in preference to pneumonectomy. A fused or underdeveloped fissure, with a normal contiguous lobe, does not necessarily call for a total resection.

At times when upper lobectomy has been elected as the most promising form of treatment, exploration may reveal sufficient involvement in other lobes to contraindicate lobectomy. Here the surgeon must decide whether to perform a more extensive resection or abandon resection in favor of thoracoplasty. Such a decision would have to be based on the type of disease, the presence of endobronchial tuberculosis, and the status of the contralateral lung.

Segments or fused lobes can be enucleated from surrounding segments precisely. Overholt and Langer[3] have described a method of segmental dissection which follows the avascular intersegmental plane and can be accomplished without the use of lung clamps, hemostatic forceps, or suturing of the cut lung surface. The method recognizes the fact that each segment is bound within the lobe by four principal structures: the bronchus, the artery, the vein, and the visceral pleura. These structures can be divided prior to the actual dissection of the segment. This method has the advantages of complete and precise segmental enucleation without traumatization of adjacent lung parenchyma. Absence of lung suturing retains the normal volume of the remaining segment. It is consoling to know that the surgeon is not now forced, for technical reasons, to resect more lung than is necessary.

Closure.—Every effort is made to restore the mechanical efficiency and integrity of the chest wall. A stable chest is necessary for proper interchange of gases and for the natural expulsive force of the cough mechanism. A painful wound is to be avoided. It is well known that pain impairs the efficiency of cough. For the past year we have found that the use of pericostal wire sutures, or metal bands, effectively stabilizes the thoracic cage. Janes[4] has pointed out that if the sutures are carefully applied beneath the periosteum, pain is greatly reduced or abolished (see Fig. 4).

Drainage of the Pleural Cavity.—In lobectomy cases, the space is drained with two rubber catheters (size 24). These are left emerging through the anterior end of the wound. The catheters are attached to a suction apparatus with a negative pressure of 12 cm. of water. These tubes are removed in twenty-four to forty-eight hours. The suction of air and fluid facilitates reexpansion of the remaining lobes.

In pneumonectomy cases, drainage is not used. The intrapleural pressure is reduced to negative readings by needle aspiration. When pneumonectomy has been performed in post-thoracoplasty cases, the pleural cavity is drained with a rubber catheter which is attached to an underwater drainage for twenty-four to forty-eight hours. The small pleural space increases likelihood of rapid pressure changes, and aspiration may be difficult; hence, temporary drainage is carried out in these patients.

We have learned that too much simultaneous manipulation at the conclusion of the operation favors shock or disturbing vagovagal reflexes. After a spica dressing of elastoplast is applied to the shoulder and chest, the patient is transferred to a bed directly from the operating table. This eliminates another transfer in the patient's room. Next, a thorough endotracheal aspiration is carried out. Careful auscultation of the chest is done to make sure that airways are free of secretions. The intratracheal tube is then removed

as the final step of the operation. The cough reflex returns soon after the endotracheal tube is removed. The patient is conscious and able to cough effectively.

Immediate Postoperative Care.—Blood pressure, pulse, and respirations are checked postoperatively and, if satisfactory, the venoclysis is discontinued immediately. Most patients can take fluids and nourishment by mouth without delay.

The patient is placed in Trendelenburg position until the blood pressure has been stabilized. An open tent, providing approximately a 40 per cent oxygen concentration is used for a few hours. The patient is placed on the side operated upon at first but is turned at least every hour. Undue pain should be relieved by sedation but oversedation is harmful. Patients are encouraged to cough and raise all bronchial secretions. Manual support of the chest wall during the periods of coughing is given by the nurse to assist the patient. Tincture of benzoin steam inhalations are often beneficial. If all of these simpler measures prove ineffective, tracheal aspiration with an intranasal catheter, or bronchoscopic aspiration, should be used without delay.

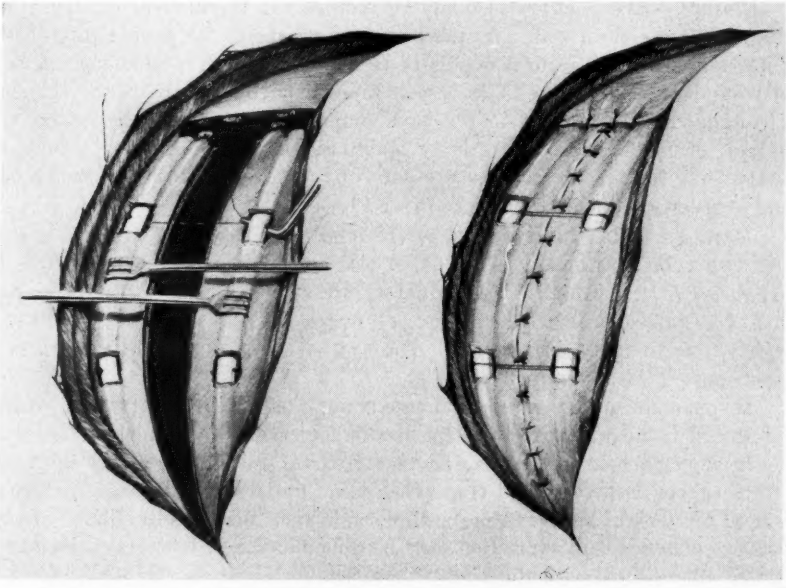


Fig. 4.—Drawings showing the use of pericostal wire sutures of stainless steel (size 35) for reconstruction of the costal cage in closure of the chest. The ribs are completely denuded of periosteum for about 1 cm. Notches are made in the rib edge to prevent the suture from sliding. The intercostal nerves are carefully excluded. Postoperative pain has been greatly reduced. In most cases less than three hypodermic injections of morphine are needed in each of the postoperative days, and for many patients hypodermic medication is unnecessary. In pneumonectomy cases where a rib is removed, the periosteal bed, intercostal muscles, and the pleura are approximated with interrupted silk sutures. A drain is not used. In lobectomy cases, the intercostal muscle is sutured with interrupted silk if there is tissue available. The longissimus dorsi muscle is drawn over the region of the resected portions of the ribs and sutured to the pericostal tissue. The muscles are closed in two layers with interrupted silk sutures. The subcutaneous fascia and the skin are likewise closed in separate layers with interrupted silk. Multiple-needle technique is used for the skin.

The position of the mediastinum is checked by fluoroscopy or x-ray examination at regular intervals during the first week, or until stabilization occurs. In the average pneumonectomy case, needle aspiration of pleural fluid is required upon one or two occasions.

Post-Resection Thoracoplasty.—

Postpneumonectomy: After pneumonectomy we have made it a routine practice to do a two-stage thoracoplasty on the resected side. This prevents overdistention of the contralateral lung. We also believe that it will reduce the possibility of reactivation of a subclinical or a quiescent contralateral lesion.

The first stage, an anterolateral operation, is usually done six weeks after the resection. The cartilages and the anterior segments of the second, third, and fourth ribs on the left are removed. On the right side we also remove an anterior segment of the fifth rib. Ten to fourteen days later, the posterior stage is done through the posterior scar with the removal of the remaining portions of the second, third, fourth, and fifth ribs. The sixth rib was removed at the time of the resection. If the tip of the scapula impinges upon the seventh rib, either a portion of this rib or the tip of the scapula is removed. The first rib is left intact as are the transverse processes. This maintains the upper thoracic aperture and minimizes scoliosis. This limited costal resection provides a sufficient shift of the chest wall to maintain proper position of the mediastinum.

Postlobectomy: In upper lobectomy cases, one-stage upper thoracoplasty is performed through the previous incision. The first rib is left intact, but the entire second, third, and the posterior portions of the fourth rib are removed. The transverse processes again are left intact. In lower lobectomy cases a permanent phrenic paralysis is carried out about ten days following resection.

Late Postoperative Care.—Pulmonary resection should always be supplemented by a period of complete bed rest. It is erroneous to believe that all of the tuberculous tissue is extirpated as a result of resection. We, therefore, advise a period of six months of complete bed rest following sputum conversion. It is needless to say that this rest period should be extended if there is any question of tuberculous activity in the remaining lung tissue. We feel that all resection cases should be bronchoscoped for examination of the bronchial stump. An attempt is made to do this within six months of the resection, and earlier if there is a suspicion of bronchial lesion. Ulceration of the stump is treated with 30 per cent silver nitrate and is repeated at two- to four-week intervals, if necessary.

GENERAL STATISTICS, POSTOPERATIVE COMPLICATIONS, AND RESULTS

General Statistics.—The present report deals with 200 consecutive pulmonary resections performed in 192 tuberculous patients between 1934 and April 5, 1946. In Table I are given the general statistics. The entire series has been divided into three groups. This was done because of significant variations in operative and anesthetic techniques during three periods.

TABLE I. GENERAL STATISTICS

	GROUP I (1934 TO JAN. 1, 1942)	GROUP II (JAN. 1, 1942, TO MARCH 31, 1944)	GROUP III (MARCH 31, 1944, TO APRIL 5, 1946)	TOTAL
Number of patients	17	71	107	192
Number of resections	18	74	108	200
Pneumonectomies	11	47	69	127
Right	5	18	23	46
Left	6	29	46	81
Lobectomies	7	27	39	73
Right upper	0	7	13	20
Right upper and middle	1	1	5	7
Right lower and middle	2	2	5	9
Right lower	0	5	2	7
Left upper	0	8	7	15
Left lower	3	4	3	10
Right upper and superior division of right lower	0	0	2	2
Segmental resection of left upper	0	0	2	2
Left lower and lingula of left upper	1	0	0	1
Age of patients	16 to 57 yr.	15 to 54 yr.	17 to 64 yr.	
15 to 20 yr.	1	1	3	
20 to 30 yr.	5	31	42	
30 to 40 yr.	10	31	47	
40 to 50 yr.	1	7	12	
50 to 60 yr.	1	4	3	
60 to 70 yr.	0	0	1	
Sex				
Females	15	59	67	141
Males	3	15	41	59
Incidence of tuberculous bronchitis	11 (61.1%)	24 (32.5%)	35 (32.4%)	70 (35%)
Submucosal	1	4	12	
Ulcerative	0	4	3	
Ulcerostenosis	0	10	9	
Fibrostenosis	10	6	11	
Duration of disease				
Under 6 mo.	0	6	9	15
6 mo. to 1 yr.	1	8	9	18
1 to 2 yr.	3	22	17	42
2 to 3 yr.	1	8	16	25
3 to 4 yr.	2	7	17	26
4 to 5 yr.	2	5	8	15
5 to 6 yr.	3	5	4	12
6 to 7 yr.	1	4	8	13
7 to 8 yr.	0	0	2	2
8 to 9 yr.	0	1	7	8
9 to 10 yr.	0	2	0	2
10 to 15 yr.	4	3	6	13
15 to 20 yr.	0	3	3	6
Unknown	1	0	0	1
Survey lesions	0	0	2	2
Incidence of positive sputum	7 (63.6%)	68 (91.8%)	87 (80.5%)	162 (81%)
Operative risk				
Reasonable risk	11	57	90	158
Desperate risk	7	17	18	42

The total number of patients is 192 because eight patients had two resections.

Group I represents eighteen pulmonary resections (eleven pneumonectomies and seven lobectomies) performed between 1934 and Jan. 1, 1942. During this time the pre- and postoperative care, the criteria for selection of patients, and the operative technique were not well standardized. The tourniquet technique

was used in three cases. The pleural flap method of closing the bronchus was not used routinely. All patients were operated upon in the conventional side position, under general anesthesia.

Group II represents seventy-four resections (forty-seven pneumonectomies and twenty-seven lobectomies) performed between Jan. 1, 1942, and March 31, 1944. During this time the operative technique was well standardized. Individual ligation of hilar structures and the pleural flap method of closing the bronchus were used routinely. However, all patients were operated upon in the conventional side position, under general anesthesia.*

Group III represents 108 resections (sixty-nine pneumonectomies and thirty-nine lobectomies) performed between March 31, 1944, and April 5, 1946. During this period, the side position of the patient during operation and general anesthesia were abandoned. All except twelve patients were operated upon in the face-down position and all except seven under a combination of paravertebral block and local infiltration with novocain.

The age of the patients ranged from 15 to 64 years. Note that nine patients were over 50 years of age.

There were 141 females and 59 males. The preponderance of women may be explained, somewhat, by the high incidence (35 per cent) of tuberculous bronchitis in the group. Most reports indicate that this complication is more common in women.

The analysis of the duration of the disease is important. Fifteen patients (7.5 per cent) had been ill less than six months and fifty-six (28 per cent) for more than five years. In fact, nineteen patients (9.5 per cent) had been ill for more than ten years.

One hundred sixty-two patients (81 per cent) had positive sputum at the time of resection. Those with negative sputum are represented largely by those with tuberculomas and those with residual bronchiectasis after the tuberculosis had been controlled.

Of the 200 patients, 158 were considered to be reasonable risks and 42 to be desperate risks. Those classified as desperate risks were otherwise utterly hopeless cases. In the opinion of every clinician taking care of them, no other form of therapy could be used and pulmonary resection offered them their only chance to get well. Any salvage in this group can be considered pure gain. We feel that attention should be called to this group of desperate risks because, in our opinion, they represent a type of patient never accepted for collapse therapy in the past and who has entered surgical statistics for the first time.

Indications.—In Table II are presented the indications for the 200 resections. Again the statistics have been divided into three groups to enable the reader to compare the types of cases accepted for resection. In twelve cases resection was performed because of bronchiectasis in patients whose tuberculosis had been controlled by previous collapse therapy. In eight cases resection was indicated by the presence of both suppurative disease and

*All patients in Group I and all but the last fourteen of Group II were included in Preliminary Report.[1, 2]

TABLE II. INDICATIONS IN TWO HUNDRED RESECTIONS, 1934 TO APRIL 5, 1946

INDICATIONS	GROUP I (1934 TO JAN. 1, 1942)		GROUP II (JAN. 1, 1942, TO MARCH 31, 1944)		GROUP III (MARCH 31, 1944, TO APRIL 5, 1946)		TOTAL
Associated suppurative disease	8		3		9		20
Tuberculosis controlled		4		3		5	
Tuberculosis uncontrolled		4		0		4	
Post-thoracoplasty, uncontrolled disease	4		12		16		32
No endobronchial tuberculosis		2		9		9	
With endobronchial tuberculosis		2		3		7	
Extensive predominantly unilateral tuberculosis	6		36		52		94
No endobronchial tuberculosis		1		15		34	
With endobronchial tuberculosis		5		21		18	
Upper lobe disease	0		10		18		28
No endobronchial tuberculosis				10		15	
With endobronchial tuberculosis				0		3	
Basal disease	0		10		8		18
No endobronchial tuberculosis		0		10		7	
With endobronchial tuberculosis		0		0		1	
Tuberculoma	0		1		5		6
Bilateral upper lobe giant cavities	0		2		0		2
Total resections	18		74		108		200

active tuberculosis. In the remaining 180 cases resection was performed as a specific type of therapy for the tuberculous infection itself.

The remainder of the table is self-explanatory, but we should like to call attention to the second and third indications, which include 126 cases or 63 per cent of all of the cases. Thoracoplasty failure was the indication in thirty-two patients. Twelve of the group had a complicating tuberculous bronchitis and seven previously had a revisional thoracoplasty. Extensive, predominantly unilateral disease was the most common indication (ninety-four cases). Forty-four or 46.8 per cent of this group had tuberculous bronchitis. Many of them had rapidly spreading, exudative and caseous pneumonic lesions. Some had large, tension cavities associated with extensive parenchymal infiltration. Others had multiple cavities throughout the lung or a combination of apical and basal cavities. Several had extensive, active lesions which were predominantly basal in distribution. By and large, this group of patients represents a group with extensive, complicated forms of tuberculosis. Contraindications to thoracoplasty were present in a high percentage. In those in whom thoracoplasty might have been tried, extensive thoracoplasty approaching complete collapse would have been required. Naturally, most of the desperate risks fall into this group.

With such a categorical list of indications, it is difficult, if not impossible, to convey an accurate concept of the type of case in which treatment has been by resection. A consideration of the following facts will give a truer picture:

1. Seventy-five patients (37.5 per cent) had tuberculous lesions in the contralateral lung (calcified lesions and primary complexes not included).

2. Twelve patients (6 per cent) had previous collapse therapy of the contralateral lung; eleven with pneumothorax and one with phrenic. Four pa-

tients had contralateral pneumothorax at the time of lobectomy. One previously had a contralateral tuberculous empyema complicating the pneumothorax.

3. Three patients (1.5 per cent) had tuberculous empyema at time of resection (two mixed and one pure infection).

4. Six patients (3 per cent) had been treated previously by cavernostomy, in five of whom drainage was still taking place at the time of resection.

5. One patient (0.5 per cent) had had two paraffin plombages.

6. Nine patients (4.5 per cent) had had a previous lobectomy.

7. Thirty-two patients (16 per cent) had been treated by thoracoplasty and seven of the group had also had revisional thoracoplasty.

8. Only fifty-eight patients (29 per cent) had no collapse therapy prior to resection. The remaining 142 patients (71 per cent) represent a group of collapse therapy failures with the resulting complications and impairment of pulmonary functional reserve.

9. Fifty-six patients (28 per cent) had been ill for more than five years and nineteen (9.5 per cent) for more than ten years. Most of these had not only been subjected to multiple collapse therapy measures but also to years of tuberculous toxemia.

10. Seventy patients (35 per cent) had a complicating tuberculous bronchitis.

Postoperative Complications Related to Tuberculous Infection Following Lobectomy.—In Table III are presented the postoperative complications which occurred following lobectomy. They have been divided into three groups according to the technique used as described under the general statistics. Here again, the table explains itself but the following points bear emphasis.

Tuberculous wound infections: No tuberculous wound infections have occurred in any of the three groups.*

Empyema and fistula: In Group I, three patients (42.8 per cent) had permanent fistulas. As a result they developed tuberculous empyemas. In the same group two patients (28.6 per cent) had temporary fistulas. They developed nontuberculous empyemas which healed completely. Thus, in this early period between 1934 and Jan. 1, 1942, all empyemas were associated with fistulas. No empyema, tuberculous or nontuberculous, occurred without fistula. Since Jan. 1, 1942 (Groups II and III), there has been one permanent fistula. The only evidence for the fistula was a small cap of air over the lung. The fistula was not recognized and the patient was discharged from the sanatorium one year later. He returned ten months later with extensive bilateral spread, and died. Only one temporary fistula has occurred. This was closed with a free muscle transplant and limited thoracoplasty. The patient did not develop an empyema and was clinically well with negative sputum three years following operation. Since Jan. 1, 1942, sixty-two consecutive lobectomies have been performed with only one empyema and this was secondary to fistula. The incidence of fistula and empyema is lower following lobectomy than after

*No major wound sepsis of a nontuberculous nature has occurred in any case of any of the groups.

TABLE III. LOBECTOMIES; POSTOPERATIVE COMPLICATIONS RELATED TO TUBERCULOUS INFECTION

	GROUP I (1934 TO JAN. 1, 1942) 7 LOBECTOMIES		GROUP II (JAN. 1, 1942, TO MARCH 31, 1944) 27 LOBECTOMIES		GROUP III (MARCH 31, 1944, TO APRIL 5, 1946) 35 LOBECTOMIES	
	NUMBER	PER CENT	NUMBER	PER CENT	NUMBER	PER CENT
Tuberculous wound infection	0	0.0	0	0.0	0	0.0
Tuberculous empyema						
With fistula	3	42.8	1	3.7	0	0.0
Without fistula	0	0.0	0	0.0	0	0.0
Nontuberculous empyema						
With fistula	2	28.6	0	0.0	0	0.0
Without fistula	0	0.0	0	0.0	0	0.0
Fistula						
Temporary	2	28.6	1	3.7	0	0.0
Permanent	3	42.8	1	3.7	0	0.0
Contralateral spread	1	14.3	2	7.4	1	2.8
Contralateral exacerbation	0	0.0	0	0.0	0	0.0
Tuberculosis of chest wall	0	0.0	0	0.0	0	0.0
Ipsilateral spread	0	0.0	1	3.7	1	2.8
Ipsilateral exacerbation	0	0.0	3	11.1	0	0.0
Ulceration of bronchial stump	0	0.0	0	0.0	0	0.0

pneumonectomy. The rapid re-expansion of the lung following lobectomy with the resulting obliteration of the pleural space and support to the area of bronchial closure undoubtedly accounts for this.

Contralateral spread and exacerbation: Nineteen of the patients treated by lobectomy had contralateral lesions. Exacerbation occurred in none of these.

Contralateral spread has occurred in four patients, an incidence of 5.8 per cent. The incidence for the three groups was 14.3, 7.4, and 2.8 per cent respectively.

Ipsilateral spread and exacerbation: Ipsilateral spread has occurred in only two patients (2.9 per cent).

Ipsilateral exacerbation during the postoperative period occurred in three patients of Group II and in none of the patients of Groups I and III, a total incidence of 4.3 per cent. Operative trauma and the stress and strain placed upon remaining tuberculous foci by the re-expansion and overdistention of the remaining lobes are probably the most important causes of early ipsilateral exacerbation.

Segmental Resection Four Cases.—During the past year segmental resection has been applied in four cases. The technique used was that of Overholt and Langer, previously described in this paper. In two cases, the right upper lobe and superior segment of the right lower lobe were resected. In the other two, the apical-posterior segment of the left upper lobe was resected. No postoperative complications occurred in three of these. One patient who had a cavity in the left upper lobe, removed by resection of the posterior-apical segment, had both ipsi- and contralateral spreads and developed a bronchial fistula with tuberculous empyema. The fistula has since been closed by a plastic procedure, the empyema space drained, and thoracoplasty performed. Only a small sinus tract remains. The parenchymal disease on both sides is clearing rapidly. The patient's general condition is good and the sputum is negative.

Postoperative Complications Related to Tuberculous Infection Following Pneumonectomy.—In Table IV are presented the statistics for postoperative complications in patients treated by pneumonectomy.

TABLE IV. PNEUMONECTOMIES; POSTOPERATIVE COMPLICATIONS RELATED TO TUBERCULOUS INFECTION

	GROUP I (1934 TO JAN. 1, 1942) 11 PNEUMONECTOMIES		GROUP II (JAN. 1, 1942, TO MARCH 31, 1944) 47 PNEUMONECTOMIES		GROUP III (MARCH 31, 1944, TO APRIL 5, 1946) 69 PNEUMONECTOMIES	
	NUMBER	PER CENT	NUMBER	PER CENT	NUMBER	PER CENT
Tuberculous wound infection	0	0.0	0	0.0	4	5.8
Tuberculous empyema						
With fistula	1	9.1	2	4.2	2	2.9
Without fistula	0	0.0	1	2.1	5	7.2
Nontuberculous empyema						
With fistula	0	0.0	0	0.0	0	0.0
Without fistula	1	9.1	4	8.5	1	1.4
Fistula						
Temporary	0	0.0	0	0.0	0	0.0
Permanent	2	18.2	2	4.2	2	2.9
Contralateral spread	1	9.1	9	19.1	7	10.1
Contralateral exacerbation	0	0.0	2	4.2	5	7.2
Ulceration of bronchial stump	0	0.0	1	2.1	1	1.4
Tuberculosis of chest wall	0	0.0	3	6.4	2	2.9
Contralateral spread secondary to fistula	1	9.1	1	2.1	0	0.0

*Tuberculous wound infections:** In Groups I and II, fifty-eight pneumonectomies were performed without any wound infection. In Group III, four tuberculous wound infections have occurred in the postoperative period. One patient had a tuberculous empyema at the time of resection. The wound infection in this case can be readily understood. The remaining three had tuberculous empyema following resection. Whether or not the wound infection in these three cases has been the result of operative contamination or has been secondary to tuberculous empyemas is still an unsettled question. In the earlier groups none of the empyemas were associated with wound infection. The only significant alteration in technique was that in two of these patients large cavities were intentionally opened and aspirated before the lung was mobilized in an effort to avoid contralateral spread.

Tuberculous Empyema and Fistula: The incidence of fistula has been reduced progressively in all three groups, being 18.2, 4.2, and 2.9 per cent, respectively. This represents a total of 6 out of 127 pneumonectomies, an incidence of 4.7 per cent.

The fact that the incidence of tuberculous empyema secondary to fistula has been lowered with the reduction of the incidence of fistula needs no explanation. However, the definite increase of tuberculous empyemas not associated with fistula in the most recent group of cases bears mention. Tuberculous empyema has occurred in five of the last sixty-nine pneumonectomies, an incidence of 7.2 per cent. Cavities were opened and aspirated at the time of

*No major wound sepsis of a nontuberculous nature has occurred in any case of any of the groups.

operation in two of these patients in an attempt to prevent contralateral spread. This may have been the source of contamination in these cases. The remaining three cases represent an unexplained increase in the incidence of tuberculous empyema.

Contralateral spread: In Group I, contralateral spread occurred in only one of eleven patients (9.1 per cent). This low incidence may be accounted for somewhat by the high percentage (36.4 per cent) of patients in this group in whom the indication was associated suppuration with the tuberculosis controlled.

In Group II this complication occurred in nine of forty-seven patients (19.1 per cent) and in Group III in seven of sixty-nine patients (10.1 per cent). The operative technique in these two groups was the same except for the anesthesia and the position of the patient during operation. Those in Group II were operated upon in the side position, under general anesthesia. Those in Group III were operated upon in the face-down position, under paravertebral block and local infiltration with novocain. This reduction in contralateral spread is attributed to these factors. It cannot be accounted for by the type of case accepted for operation as those in Group III represent patients with lesions just as extensive and active, if not more so, than those in Group II. In spite of all changes in techniques, contralateral spread still remains the greatest threat to the tuberculous patient coming to resection.

Contralateral exacerbation: Contralateral exacerbation has occurred in the three groups as follows: none in the first, 4.2 per cent in the second, and 7.2 per cent in the third. We have no explanation for this increase. Possibly in recent years a willingness to accept patients with contralateral lesions of more doubtful stability may be the answer.

Ulceration of bronchial stump: These statistics are not significant because most of the stump ulcers become evident later than the postoperative period and fall into the late complications. Both patients listed in Table IV had tuberculous bronchitis prior to operation and in one the bronchial suture line was placed through an area of the bronchus actively involved by an ulcerohyperplastic lesion.

Tuberculosis of chest wall: Tuberculosis of the chest wall is a complication which was discovered at the time of the postresection thoracoplasty. In every case the wound healed by primary intention following resection and there was no evidence of the underlying infection. The tuberculous infection was evident only after the incision was made for the thoracoplasty. This has occurred in five cases. Thoracoplasty was performed on all five patients in spite of the tuberculous infection in the chest wall. Three of the wounds healed by primary intention and have remained free of evidence of infection. One has a small draining sinus. The other has a localized wound infection associated with a late tuberculous empyema.

Postoperative Complications Related to Surgical Problem of Pulmonary Resection and Associated Diseases.—In Table V are listed the complications that have occurred following both lobectomy and pneumonectomy that are not related to the tuberculous infection itself. One patient died of diabetic coma on the

fourth postoperative day following pneumonectomy. The carbon dioxide combining power of the blood was 19 volumes per cent. Autopsy showed that the patient did not have any other complication.

Pulmonary insufficiency occurred following two pneumonectomies and one bilateral upper lobectomy. The two patients with pneumonectomy died of this complication in the postoperative period. The patient with bilateral upper lobectomy died two years later of progressive bilateral disease. Pulmonary insufficiency in this case was caused by both the amount of tissue resected and the involvement of the remaining lung tissue.

Pulmonary embolus caused the death of one patient on the fifteenth postoperative day following pneumonectomy.

Postoperative shock was the cause of death following one pneumonectomy and one lobectomy.

Cardiac arrest caused two operative deaths. One occurred following the postoperative bronchoscopy. The other occurred following temporary obstruction of the contralateral bronchus by secretions.

Pulmonary edema caused the death of one patient following pneumonectomy. This was proved by autopsy. The death can be charged, directly, to bad judgment as to the speed of administration and the amount of saline solution given during and following the operation.

TABLE V. POSTOPERATIVE COMPLICATIONS RELATED TO SURGICAL PROBLEM OF PULMONARY RESECTION

	GROUP I (1934 TO JAN. 1, 1942)	GROUP II (JAN. 1, 1942, TO MARCH 31, 1944)	GROUP III (MARCH 31, 1944, TO APRIL 5, 1946)	TOTAL
Diabetic coma	1	0	0	1
Pulmonary insufficiency	1	2	0	3
Pulmonary embolus	0	1	0	1
Postoperative shock	0	1	1	2
Cardiac arrest	0	1	1	2
Pulmonary edema	0	0	1	1
Cardiac failure	0	0	1	1
Acute edema of glottis	0	0	1	1
Unexplained sudden death	0	0	1	1
Paroxysmal heart action	0	1	0	1
Peripheral vascular collapse	0	1	0	1

Cardiac failure caused the death of one patient following pneumonectomy on the forty-third postoperative day. This patient was forty-eight years of age, had been ill for seven years, and previously had had thoracoplasty and a revision. In addition, he had amyloidosis. He was a desperate risk and was accepted for resection as such.

Acute edema of the glottis occurred a few hours following pneumonectomy in one patient. In reality, this is a complication of tuberculous laryngitis, the edema being due to irritation by the endotracheal tube.

One patient died suddenly a few hours following lobectomy. During operation and just a few minutes before death the blood pressure had been normal and at no time were signs of shock manifested. Autopsy was not obtained and the death is unexplained.

One patient died on the first postoperative day following pneumonectomy of paroxysmal heart action. The irregularity of the pulse developed while the nurse was taking the pulse. Within a few minutes the patient was dead.

One patient died on the second postoperative day, apparently of peripheral vascular collapse. Her condition had been satisfactory until the blood pressure suddenly dropped and pulse became imperceptible. There were no signs of mediastinal shift or respiratory distress.

Fatality Statistics.—

Lobectomy: In Table VI are given the operative and total case fatalities to date for the sixty-nine patients treated by lobectomy. The high operative fatality in Group I was the direct result of poor selection of cases and inferior operative technique. Since Jan. 1, 1942, there have been three deaths in sixty-two consecutive lobectomies, a mortality rate of 4.8 per cent. The causes of death in these three patients were as follows: (1) contralateral spread, (2) operative shock, and (3) sudden, unexplained death a few hours following resection. At no time had this patient shown any signs of shock.

TABLE VI. FATALITY STATISTICS; LOBECTOMY

Operative fatality (69 lobectomies)		
Group I (1934 to Jan. 1, 1942)	28.6%	(2 of 7)
Group II (Jan. 1, 1942, to March 31, 1944)	3.7%	(1 of 27)
Group III (March 31, 1944, to April 5, 1946)	5.7%	(2 of 35)
Total	7.3%	(5 of 69)
Case fatality (68 patients)		
Group I (1934 to Jan. 1, 1942)	42.9%	(3 of 7)
Group II (Jan. 1, 1942, to March 31, 1944)	11.5%	(3 of 26)
Group III (March 31, 1944, to April 5, 1946)	11.4%	(4 of 35)
Total	14.7%	(10 of 68)

There have been five late deaths in the lobectomy groups. One patient in Group I died six years following operation, of contralateral disease. There were two late deaths in Group II. One patient died of bilateral spread secondary to fistula twenty-two months after operation. The other patient previously mentioned, had bilateral, giant, upper lobe cavities and was treated by bilateral upper lobectomy. Death was caused by progressive disease in both lungs and pulmonary insufficiency. Both late deaths in Group III were caused by progressive disease following lobectomy. One patient, 64 years old, had diabetes. The other had previously had cavernostomy performed to drain a giant cavity of the right lower lobe. Following resection, a contralateral spread occurred and later the remaining ipsilateral disease progressed.

Pneumonectomy: In Table VII are presented the operative and total case fatalities to date for the 127 patients treated by pneumonectomy.

Twenty-two (17.3 per cent) of the 127 patients died in the postoperative period. The operative fatalities in Groups I and II are almost the same, being 27.3 and 23.4 per cent, respectively. A drop in operative mortality to 13 per cent in Group III is significant, since the type of case selected during this period was just as serious as in the earlier groups. The causes of the postoperative deaths in the three groups are as follows:

TABLE VII. FATALITY STATISTICS; PNEUMONECTOMY

Operative fatality (127 pneumonectomies)		
Group I (1934 to Jan. 1, 1942)	27.3%	(3 of 11)
Group II (Jan. 1, 1942, to March 31, 1944)	21.3%	(10 of 47)
Group III (March 31, 1944, to April 5, 1946)	13.0%	(9 of 69)
Total	17.3%	(22 of 127)
Case fatality (127 pneumonectomies)		
Group I (1934 to Jan. 1, 1942)	54.5%	(6 of 11)
Group II (Jan. 1, 1942, to March 31, 1944)	38.3%	(18 of 47)
Group III (March 31, 1944, to April 5, 1946)	17.4%	(12 of 69)
Total	28.3%	(36 of 127)

GROUP I

(1) Diabetic coma
(2) Pulmonary insufficiency
(3) Contralateral spread

GROUP II

(1) Contralateral exacerbation
(2) Paroxysmal heart action
(3) Circulatory collapse
(4) Pulmonary embolus
(5) Pulmonary insufficiency
(6) Postoperative shock
(7) Cardiac standstill
(8) Contralateral spread (two cases)
(9) Fistula, empyema, contralateral spread

GROUP III

(1) Cardiac failure
(2) Acute edema of glottis
(3) Contralateral spread (four cases)
(4) Cardiac standstill
(5) Fistula, empyema, contralateral spread

In Group I there have been three late deaths. The causes of death were as follows: (1) empyema, pneumonia, and uremia, occurring six months after operation; (2) sudden death on the street eighteen months following operation; and (3) sudden death on the third postoperative day following plastic closure of bronchial fistula two and one-quarter years after resection.

There were eight late deaths in Group II. Seven of these deaths were caused by contralateral disease. The other patient died of extensive, disseminated tuberculosis of the remaining lung, tuberculous enteritis, tuberculous empyema, and amyloidosis.

There have been three late deaths in Group III. Two were caused by contralateral disease and one by empyema and contralateral disease. The follow-up period in this group of cases has been too short to be significant.

Present Clinical Status of Sixty-Eight Patients Treated With Lobectomy.—In Table VIII is analyzed the present clinical condition of the sixty-eight patients treated with lobectomy. The classification of patients has been based upon the data secured from the physicians caring for them.

TABLE VIII. PRESENT CLINICAL STATUS FOLLOWING LOBECTOMY (68 PATIENTS)

	GROUP I (1934 TO JAN. 1, 1942) 7 PATIENTS		GROUP II (JAN. 1, 1942, TO MARCH 31, 1944) 26 PATIENTS		GROUP III (MARCH 31, 1944, TO APRIL 5, 1946) 35 PATIENTS	
	NUMBER	PER CENT	NUMBER	PER CENT	NUMBER	PER CENT
Clinically well with negative sputum	2	28.6	11	41.8	20	57.00
Clinically well with negative sputum but with unstable x-ray lesion	0	0.0	1	3.8	0	0.00
Clinically well with positive sputum	0	0.0	1	3.8	3	8.50
Living with progressive disease	1	14.3	3	11.4	0	0.00
Dead	3	42.9	3	11.4	4	11.40
Came to second resection	1	14.3	6	22.8	1	2.85
Refused contralateral thoracoplasty	–	–	1	3.8	–	–
Too recent to classify	–	–	–	–	7	20.00

Group I (7 patients): The statistics of Group I represent a follow-up period of from four to twelve years. Two patients (28.6 per cent) are clinically well with persistently negative sputum. One of these is the first patient treated by resection, in 1934. One patient (14.3 per cent) is living with progressive ipsilateral disease. The sputum had been negative for nine years following resection. During the past few months the sputum has again become positive. We are hoping to salvage this patient by further resection (pneumonectomy). Three patients (42.9 per cent) are dead. Two of these died in the postoperative period and the other died six and two-thirds years following operation. The remaining patient has had a second resection because of ipsilateral exacerbation, the pneumonectomy thus having been performed in two stages. Although she is living and has a negative sputum, she has residual bronchiectasis in the other lung and is a respiratory cripple.

Group II (26 patients): The statistics of Group II represent a follow-up period of from two to four years. Twelve patients (45.6 per cent) are clinically well with negative sputum. Only one of these has an unstable x-ray lesion and this is in the contralateral lung. One patient is clinically well but has a positive sputum. The source of the positive sputum is probably bronchial ulceration although this is not visible, bronchoscopically, at the present time. Three patients (11.4 per cent) are living with progressive ipsilateral disease. One is now having thoracoplasty done and further resection is anticipated in the other two. Three patients (11.4 per cent) are dead. One died in the postoperative period. There were two late deaths. Six patients (22.8 per cent) have come to a second resection because of ipsilateral exacerbation of residual disease in remaining lobes. This is the most common late complication after lobectomy. The present status of these six patients after the second resection is as follows: Two are clinically well with negative sputum; one is clinically well with positive sputum; one has progressive contralateral disease; and two are dead.

One patient had a right upper lobectomy as a portion of a proposed bilateral program, thoracoplasty having been planned for the left side. The lobec-

tomy was successful but the patient refused thoracoplasty and was discharged from the sanatorium against advice.

Group III (35 patients): The statistics of Group III represent a follow-up period of two years or less. The figures are self-explanatory. Living patients who were operated upon after Jan. 1, 1946, are listed as "too recent to classify."

Present Clinical Status of 127 Patients Treated With Pneumonectomy.—In Table IX is analyzed the present clinical status of the 127 patients treated by pneumonectomy.

TABLE IX. PRESENT CLINICAL STATUS FOLLOWING PNEUMONECTOMY (127 PATIENTS)

	GROUP I (1934 TO JAN. 1, 1942) 11 PATIENTS		GROUP II (JAN. 1, 1942, TO MARCH 31, 1944) 47 PATIENTS		GROUP III (MARCH 31, 1944, TO APRIL 5, 1946) 69 PATIENTS	
	NUMBER	PER CENT	NUMBER	PER CENT	NUMBER	PER CENT
Clinically well with negative sputum	4	36.3	21	44.5	33	47.8
Clinically well with negative sputum but with unstable x-ray lesion	0	0.0	3	6.3	0	0.0
Clinically well with positive sputum	0	0.0	1	2.1	9	13.0
Living with progressive disease	0	0.0	4	8.5	4	5.8
Dead	6	54.5	18	38.3	12	17.4
Too recent to classify	0	0.0	0	0.0	11	15.9
Negative sputum, respiratory cripple	1	9.1	–	–	–	–

Group I (11 patients): The follow-up period in Group I ranges from four to twelve years. Four patients (36.3 per cent) are clinically well with negative sputum. Six patients (54.5 per cent) are dead. Four of these died in the postoperative period. There were two late deaths. The remaining patient is a respiratory cripple, although the sputum is consistently negative.

Group II (47 patients): The follow-up period here ranges from two to four years. Twenty-one patients (44.5 per cent) are clinically well with negative sputum. Three more patients are well with negative sputum but have unstable x-ray lesions. One patient is clinically well but has a positive sputum secondary to stump ulceration. Four patients (8.5 per cent) are living with progressive disease. Eighteen patients (38.3 per cent) are dead. Ten patients died during the postoperative period; there were eight late deaths.

Group III (69 patients): Patients in the third group have all been operated upon within the past two years. Thirty-three patients (47.8 per cent) are clinically well with negative sputum. Nine patients (13.0 per cent) are clinically well but have positive sputum. Four patients (5.8 per cent) are living with progressive disease. Twelve patients (17.4 per cent) are dead. Eleven of the living patients operated upon since Jan. 1, 1946, are listed as "too recent to classify."

DISCUSSION

During the past two years the face-down position during operation has been used in preference to the conventional side position, in our clinic. This posi-

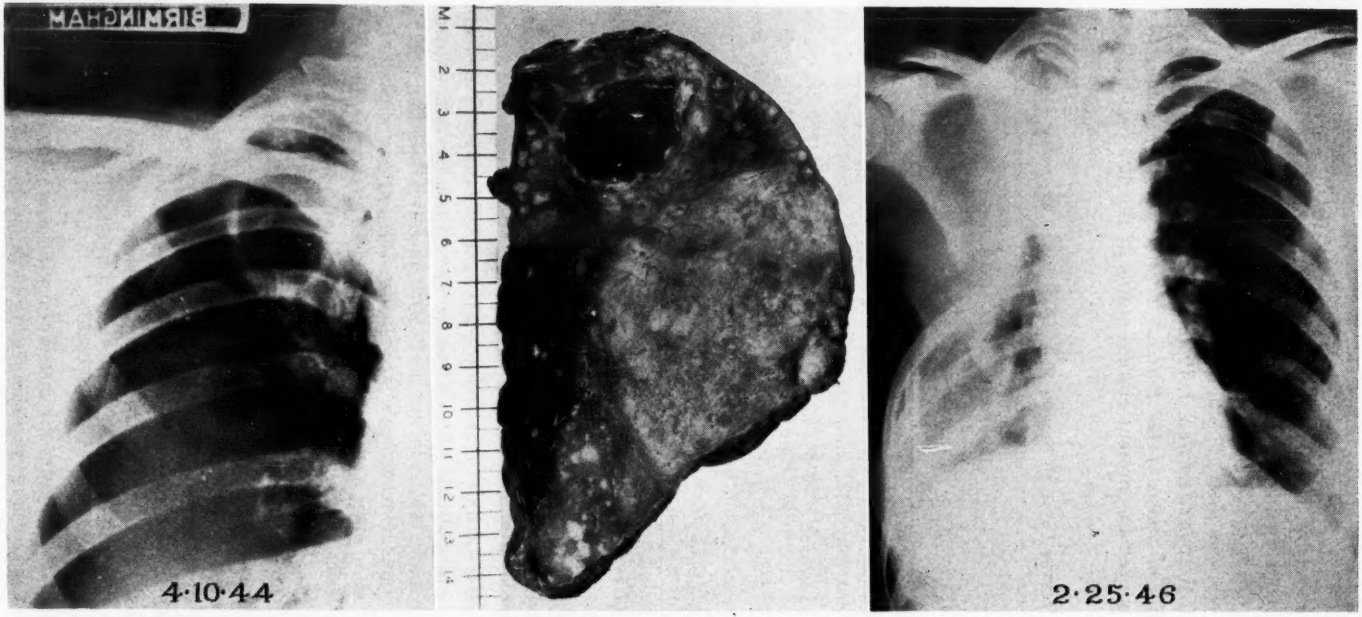


Fig. 5*A*.—*Left*, roentgenogram ten days before operation, of Mrs. D. D., aged 30 years. Roentgenogram of the chest had revealed a tuberculous lesion three years prior to operation. Pneumothorax had been instituted seven months prior to right upper lobectomy which was performed on April 20, 1944. The pneumothorax had never been effective and a large cavity remained open in the right upper lobe.

Center, the surgical specimen (right upper lobe). The large cavity and widespread caseous disease are evident.

Right, roentgenogram taken twenty-two months following operation. A modified upper thoracoplasty with partial scapulectomy has been performed. This patient has been clinically well with a persistently negative sputum since operation.

tion was originally conceived in an attempt to reduce the incidence of contralateral spread. The flow of infected secretions and debris from the bad to the good lung is favored by gravity drainage. It has been found that respiratory excursions are freer and the mediastinum shows less tendency to "swing." Open pneumothorax is tolerated without positive pressure. In addition, it has been gratifying to find that the face-down position has certain technical advantages over the side position.

Paravertebral block and local infiltration with novocain have also supplanted the use of general anesthesia. With this new technique the cough reflex is present during the operation and is immediately effective following operation. The patient is also sufficiently alert to cough up sputum. The incidence of contralateral spread has been reduced from 19 to 10 per cent due, we believe, to these two major changes in management.

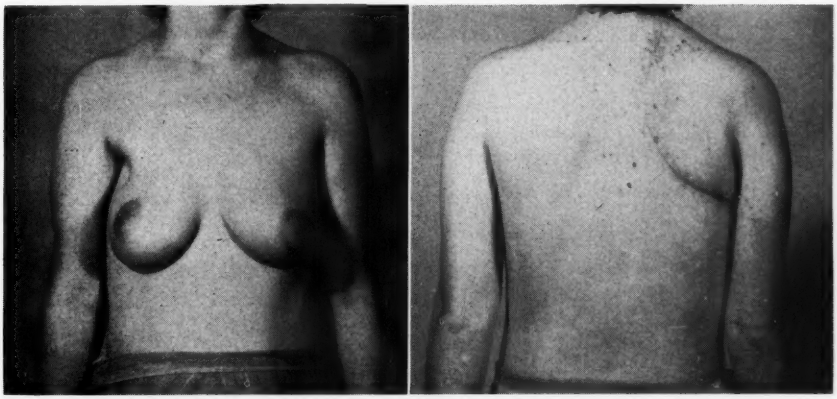


Fig. 5*B*.—Photographs of patient whose roentgenograms and surgical specimen are shown in Fig. 5*A*. Note the lack of deformity following the thoracoplasty.

In 1942 we pointed out that pulmonary resection was not a competitive, but a supplementary, form of treatment to the collapse therapy procedures. An analysis of general statistics of this series of patients leaves no doubt that this group cannot be compared with any thoracoplasty series. By and large, this series embraces a group of patients with complicated forms of tuberculosis where collapse therapy had failed or was unsuited for thoracoplasty. However, as experience with resection grew, and results improved, it seemed reasonable and logical, in certain cases, to raise the question as to whether or not resection might offer a safer and better chance to control disease than thoracoplasty in certain individual cases. Of the 200 resections, thirty-one pneumonectomies and twenty-two lobectomies were performed when thoracoplasty might have been tried first. A lobectomy was performed in preference to revisional thoracoplasty in four cases. In our series, resection was the only treatment that could have been applied in the remaining 143 patients.

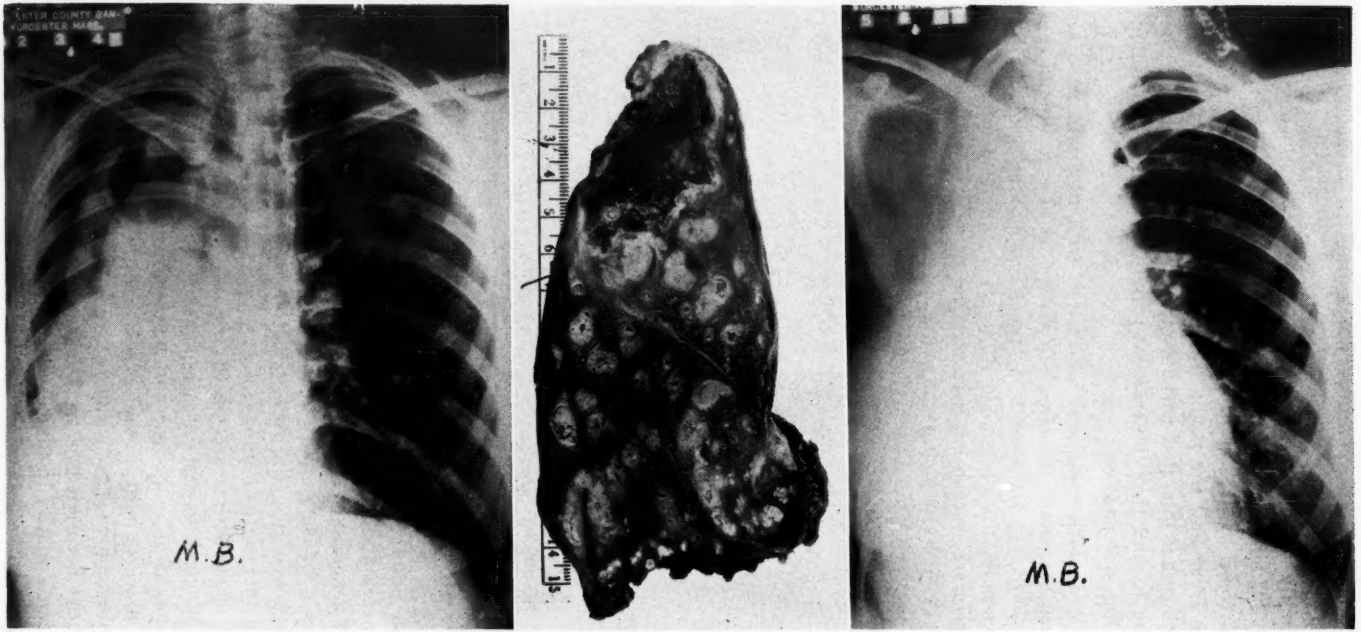


Fig. 6*A*.—*Left*, roentgenogram of chest three weeks prior to right pneumonectomy showing presence of pneumothorax, large cavity in upper lobe, and extensive involvement of the entire lung. Note the retraction of mediastinum in spite of pneumothorax. The contralateral lung is clear.

Center, this surgical specimen shows a large thick-walled cavity in the apex and disseminated caseous disease throughout the lung.

Right, roentgenogram of chest 4½ months following operation. A modified thoracoplasty has been performed. Note the lack of deformity and the normal position of the mediastinal structures.

One of the most controversial problems has been the use of upper lobectomy in preference to thoracoplasty in the treatment of tuberculous lesions that might respond to thoracoplasty. Our experience with lobectomy has been disappointing in that 48 per cent of the patients followed two to four years have developed ipsilateral exacerbation of remaining tuberculous foci. Thus, our experience indicates that upper lobectomy should not be performed as an elective procedure when there is a reasonable chance to control the lesion by thoracoplasty.

The high incidence of ipsilateral exacerbation in patients treated by lobectomy bears further mention. In Group II this complication developed in the early postoperative period in 11 per cent of the patients and in 37 per cent as a late complication. This leaves little doubt that there is considerable danger in leaving any significant amount of disease in the remaining lobes. There are two other factors that may enter into this picture: (1) trauma to residual foci during the operation and during the re-expansion of the remaining lung and (2) insufficient postresection thoracoplasty.

Fig. 6*B*.—Photographs of patient shown in Fig. 6*A*. These pictures were taken 4½ months following right pneumonectomy. A right two-stage thoracoplasty has been performed, one stage posteriorly and one anteriorly. Note the thoracoplasty scar, the lack of deformity, and the full range of motion of the right arm.

Comment: This patient was 32 years of age and had been under treatment for two years. The indications for pneumonectomy were extensive unilateral tuberculosis involving the entire lung with a large apical cavity, and a complicating ulcer-stenosis of the right upper lobe bronchus. The postoperative course was uneventful. The patient has been clinically well with persistently negative sputum (seven-day pooled concentrate) since operation.

In the lobectomy series only 16 per cent of those protected with a thoracoplasty had ipsilateral exacerbation, whereas this complication occurred in 42 per cent of those with phrenic paralysis and in 50 per cent of those without postoperative collapse of any kind. It may be that a more extensive thoracoplasty should be performed following lobectomy. Phrenic paralysis evidently gives very little protection. Following pneumonectomy the thoracoplasty should be sufficiently extensive to prevent mediastinal shift and emphysema of the contralateral lung.

In the past two years the incidence of all complications has been lowered, except for tuberculous wound infections and tuberculous empyema. The increase of these complications is attributed to operative contamination following pneumonotomy and a practice of dividing the bronchus early in the operative procedure during a retrograde dissection of the hilum in a certain number of cases. These variations in operative technique have been used in an attempt to prevent contralateral spread. However, we have now abandoned these procedures because of increase in infectious complications unless we are dealing with an extremely adherent lung and giant cavities. Under these circumstances it may be better to risk contamination of the pleura rather than risk flooding the contralateral lung with secretions and debris.

Increased experience and the employment of these newer technical advances have made pulmonary resection a progressively safer form of treatment for the tuberculous patient.* In the last two years thirty-five lobectomies have been performed with two deaths. Only two of the remaining thirty-three patients have suffered any postoperative complications. One had a contralateral spread and the other an ipsilateral spread. Thus, thirty-one or 88.5 per cent of the lobectomy cases have been carried through the resection without complications.

In the sixty-nine patients treated by pneumonectomy, nine (13.4 per cent) have died in the postoperative period. Attention has been called, earlier in this paper, to the large number of desperately ill patients in this group. Seven of the nine postoperative deaths occurred in sixteen patients previously classified as desperate risks. Thus, only two of the fifty-three reasonable risk cases died postoperatively; a fatality rate of 3.8 per cent. If a patient comes to surgery before he is in the desperate-risk or last-resort category, resection can be considered a relatively safe procedure. In those who have extensive and complicated forms of the disease with secondary infection, bronchial obstruction, fever, empyema, and reduced lung reserve from previous bilateral therapy, the operative mortality is bound to be high. Seven out of sixteen such desperate risks died.

SUMMARY

1. The face-down position of the patient during operation has reduced the incidence of contralateral spread and has technical advantages over the side position.

2. Paravertebral block and local infiltration with novocain is preferred to general anesthesia.

3. Technical maneuvers considered to be particularly important are: (a) avoidance of lung clamps; (b) avoidance of contamination from lung or cut bronchus; (c) early preliminary bronchial ligation; and (d) pleural flap reenforcement of the bronchial stump.

*In twenty-five additional patients operated upon since this paper was written, there have been no deaths, no fistulas, and no difficulties with the contralateral lung. A pneumonectomy was performed in twenty-four and a lobectomy in one. Two patients have developed a tuberculous empyema. Four cases have required treatment of the bronchial stump for ulceration, three of which were pre-existent.

4. When lobectomy is contemplated, careful exploration and appraisal of foci of disease in other lobes should be made. The danger of leaving residual disease has been emphasized.

5. The chest of the patient treated by resection should be reduced sufficiently by thoracoplasty to prevent overdistention or displacement of remaining pulmonary tissue.

6. Bronchoscopy should be performed routinely following resection to ascertain the condition of the bronchial stump.

CONCLUSIONS

Resection in the treatment of pulmonary tuberculosis has a definite place in the management of certain types of disease.

Resection finds its greatest field of usefulness when all other measures have failed or their failure is anticipated.

Resection is not a competitive form of treatment, but a supplementary one.

If pulmonary resection is to be used, the decision should be made before the patient's condition becomes desperate.

Complications and failure of other methods should be anticipated on the basis of experience and proved clinical observation.

It is the obligation of the physician to recognize certain types of tuberculosis that respond best to certain types of therapy and fail to respond to others.

It is the obligation of the thoracic surgeon to provide operative techniques which minimize complications and the hazard of the operation. Progress has been made and it is reasonable to expect further improvement.

It is necessary to follow a larger series of patients treated under modern and standardized technique for a longer period. A final appraisal of the value of resection in the treatment of tuberculosis cannot be made at this time.

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DISCUSSION ON "LOBECTOMY AND PNEUMONECTOMY IN THE TREATMENT OF PULMONARY TUBERCULOSIS" BY DR. RICHARD H. SWEET* AND "PULMONARY RESECTION IN THE TREATMENT OF TUBERCULOSIS," BY DR. RICHARD H. OVERHOLT, DR. LAZARO LANGER, DR. JOHN T. SZYPULSKI, AND DR. NORMAN J. WILSON

DR. JOHN W. STRIEDER, Brookline, Mass.—I have a much smaller series of cases than those presented by the two essayists this morning. However, I do not apologize for it because, although I have had rather more than a passing interest in the subject, I have preferred to be definitely on the conservative side in the selection of cases.

*See page 373 for article by Sweet.

I was interested that the indications, such as they are, have not changed particularly in two years. The indications which were suggested at the meeting two years ago are essentially those which are discussed today, and are the same as our indications.

There were ten lobectomies, and the indications were tuberculoma, basal cavity, and bronchiectasis. In two cases, we elected to do lobectomy where thoracoplasty might have been the operation of choice. Apical cavitation persisting with a good pneumothorax was an indication in two other cases. The indications in thirteen pneumonectomies were basal cavitation with extensive disease; thoracoplasty failure; bronchial stenosis; extensive disease; pneumothorax failure after a trial of years; and, in one case, left lower lobe atelectasis with a caseous spread following the first stage of thoracoplasty, similar to the one in Dr. Sweet's cases.

I will not take the time to go into our statistics in detail, but I will mention some significant ones which are surprisingly similar to Dr. Sweet's.

In ten lobectomies, there was one operative death, and in thirteen pneumonectomies, two operative deaths—10 and 15 per cent, respectively. The later deaths, which are, after all, the significant ones, are lobectomy, still one death, 10 per cent, and pneumonectomy, three deaths, 23 per cent.

The spreads, early and late, which again are the significant figures, rather than the early ones occurring within sixty days, are as follows: Of the lobectomies, 60 per cent had either spreads or reactivation of disease, and of the pneumonectomies, 45 per cent had either spreads or reactivation. Fortunately some of these are subsiding.

Many of these figures and of those reported this morning suggest that the extirpation of the disease is still not the philosopher's stone in the treatment of pulmonary tuberculosis. They also suggest that the imponderables, which, for want of a better term, we call the immunobiologic balance, weigh as heavily in these procedures as they ever did in a given case of pulmonary tuberculosis. If this balance can be weighted by some factors as, for example, by streptomycin, the complexion of the procedures may change. As it stands now, it seems a particularly futile gesture to remove a lobe or a lung only to have the patient succumb to the inexorable progress of the disease in the remaining pulmonary tissue.

In the evaluation of any series, I would like to call attention to a situation that undoubtedly occurs too frequently. A case is selected for lobectomy, but during the course of operation it becomes apparent that a lobectomy either cannot be done or should not be done because of the extent of the disease, therefore, pneumonectomy is performed. This case is then reported as a pneumonectomy, whereas originally, at least on the basis of films and clinical study, the indications for pneumonectomy did not exist. It seems to me that this confuses the issue.

DR. E. J. O'BRIEN, Detroit, Mich.—I think we should start out with the fact in mind, that tuberculosis is an unpredictable and a recurrent disease.

It was going through my mind, all the while I was listening this morning, what some stranger who knew little or nothing of tuberculosis would think of its treatment if he listened to these papers.

Not a word was said about thoracoplasty, pneumothorax, phrenics, pneumoperitoneum, or any other procedure. Still we know that these procedures together with bed rest will arrest the disease in a large percentage of patients. All the disease cannot be cut out often.

Dr. Overholt and Dr. Sweet said that pneumonectomy gave better results than lobectomy. Yes, because more of the disease is cut out. If the other lung were taken out too, there would be no spreads later.

If patients are treated first with the procedures I have just mentioned there will not be many of them who have disease left to do resections on.

I am amazed at the indication Dr. Overholt gave for resection:

1. Bronchiectasis. Most people with chronic tuberculosis have some bronchiectasis. This does not mean that the lobe or lobes containing it should be taken out. If the sputum is negative and not excessive in amount, of foul odor or with bleeding, it should be left alone.

2. Extensive unilateral disease. Dr. Sweet's experience showed that in just that group there are horrible results to be expected from resection. Thoracoplasties on extensive unilateral disease gave good results in between 80 and 90 per cent of patients. Then why should resection be done?

3. Basilar cavities. Just because a cavity is at the base of the lung, resection is not necessary. You have all seen these cavities closed with artificial pneumothorax, alone or with the combination of phrenic or with added pneumoperitoneum.

4. Bilateral giant cavities. Bilateral giant cavities are usually not amenable to pneumothorax, but I do not think resection is indicated in all of them. It depends on just where they are, what the pulmonary reserve is, and many other factors, but they have been grouped here as for resection.

5. Extensive disease in upper lobe. This practically completes all extensive disease and covers almost all tuberculosis except early minimal and moderately advanced disease where resection would be most likely to be effectual. Shall we then resect in all tuberculous disease? I think not.

I think Dr. Overholt's position on the table is wonderful for technical reasons. Such a beautiful operator as Dr. Overholt does not need that extra help, but it is a very helpful position. It gives a lot more room and facilitates the work. However, I cannot believe that spreads occur because of the position on the table. After all, if lipiodol is placed in a cavity, as we have done, if the patient is turned on his side and caused to cough, he will spill over the remaining lung fields. Sputum does the same thing. Prolonged operations with deep anesthesia, together with the added burden thrown on the remaining lung, will tend to cause reactivation of old disease or spreads. When the patient's cavity is properly emptied with postural drainage before operation and not over one-half hour is taken to do the job, thoracoplasty will not cause much trouble.

I think also that the immunologic factor plays a very important role in all major operations on pulmonary tuberculosis. These operations cannot be done on patients with hot active lesions without an expectation of trouble. It is bound to be so. An attempt can be made carefully with a pneumothorax or with a phrenic or pneumoperitoneum but if these patients are hit with a major procedure, that is just inviting disaster.

I do not believe that a constitutional disease can be operated upon locally (except in selected cases) with expectations of eradicating the disease. Often when roentgenograms of a patient are seen for the first time it is impossible to tell if there has been previous disease in other parts of the lung. I believe with Dr. Sweet that it is important that we see roentgenograms taken years before to detect if there has been other disease, for it is my opinion that when so-called spreads occur they are, in most cases, not spreads but old disease lighting up because of added strain. This is especially true following resection when the remaining lobes must overexpand. We believe that resection has an important place in the treatment of pulmonary tuberculosis. It is the procedure of choice in our opinion in severe bronchial stenosis, tuberculoma or coin lesion, and in some patients where collapse measures have been unsuccessful in closing cavities and controlling disease. Examples are cavities under optimum thoracoplasty, a thick-walled cavity not closed after the lung has been put down with a good pneumothorax for a considerable period of time, or basilar cavities that cannot be controlled with phrenic operation and pneumoperitoneum. It is also indicated in demonstrable bronchiectasis with positive sputum without parenchymal disease and with a clear bronchial tree. We do not believe, however, that it should be used where other procedures have a good chance to control the disease.

Certainly the results of either Dr. Sweet or Dr. Overholt cannot be compared with the results of pneumothorax, thoracoplasty, and other collapse measures.

DR. DEAN B. COLE, Richmond, Va.—The papers presented by Dr. Sweet and Dr. Overholt emphasize the limitations of curing tuberculosis by excision without detracting from the usefulness of lobectomy, pneumonectomy, or segmental resection in selected cases. I agree with Dr. O'Brien that surgical collapse measures other than excision are preferable in most cases where surgery is indicated.

We have found that patients with tuberculosis usually fall into one of three groups: (1) patients who will recover with little or no treatment; (2) patients who die regardless of treatment; (3) patients who recover with the aid of treatment, who would otherwise probably die. The latter we consider the important group for treatment; they are especially amenable to collapse therapy and related procedures.

I think this presentation is of value to all of us interested in this subject.

DR. C. P. BAILEY, Jenkintown, Pa.—In experience with eighty cases of pulmonary resection for tuberculosis I have had results intermediate between those of Dr. Overholt and Dr. Sweet. It seems to me that the factors that are important have already been brought out.

We lost seven of our ten patients with "destroyed lungs." The mortality of pneumonectomy is higher than that of lobectomy.

These cases are hardly suitable for statistical analysis. Some operations were done four years ago. Some were done one week ago. Naturally, the difference in time ruins any statistics we may have.

(Slide.) This is a tube which was invented or modified by Dr. Henry Root and myself. It is an intrabronchial anesthesia tube, the obturator of which is a 5 mm. bronchoscope.

(Slide.) This is a coil spring with rubber covering.

(Slide.) We found that spreads were directly related to the amount of sputum in these cases, and apparently related to the amount of sputum which we removed from the bronchial tree on postoperative bronchoscopy. I do not believe the bronchial tree can ever be completely evacuated on postoperative bronchoscopy. Whatever secretions get into the smaller bronchi will always cause a probable atelectasis and success in these cases must be related to the prevention of contralateral expression of secretions—not treatment but prevention.

I think the Overholt position offers a great deal, although I have had little experience with it.

However, if a patient is placed in an extreme Trendelenburg position, tipped laterally so that the bad side is down, and the modified Rienhoff incision used, the gravity principles can be used. If an intrabronchial tube is used, such as this one, or any other that can actually be put in place, contralateral spread can almost invariably be prevented.

DR. JEROME R. HEAD, Chicago, Ill.—All of us, I am sure, have been deeply interested in the subject of lung resection in pulmonary tuberculosis. Some have been adventurous enthusiasts, others have been conservative resisters, and still others have been open-minded spectators who knew that the procedure had its uses but did not know how far they extended. In this latter group I have counted myself. While conceiving of the possibility that early resection might be proved the procedure of choice in unilobar disease, I have used the older and more tested procedures first and have resorted to resection only when these measures have failed. Because of this attitude I have had very few resections to perform, for these older methods still form a fairly complete armamentarium. The experiences reported by Dr. Sweet and Dr. Overholt tend to uphold this attitude. Until some drug is found which will be effective in preventing postoperative extension of tuberculosis and in controlling small uncomplicated foci, rest and collapse will, I believe, continue to be the procedures of choice in cases in which experience has shown that there is a good chance of controlling the disease. Resection will be reserved for those cases in which collapse has been tried and has failed and for those in which experience has shown that it is not likely to be effective.

Bronchial obstruction is the chief and the most definite indication for lobectomy or pneumonectomy. Cases with this complication fall into two classes which, from the point of view of symptomatology, may be called acute and chronic. The acute type, which usually occurs early in the clinical course, is characterized by wheezing and severe explosive cough. Because this explosive cough threatens and usually results in dissemination of the infection throughout the lungs, the condition represents a surgical emergency. Unless the lobe is removed immediately, spread and eventual death are almost certain. This type is rare. More commonly the cough is not too severe and dangerous, and narrowing to almost complete occlu-

sion of the bronchus progresses without alarming symptoms. In these cases there is no emergency. Pneumothorax or thoracoplasty will often give immediate relief and permit the bronchial lesion either to heal without too great narrowing or to progress to complete obstruction with subsidence of the infection in the occluded lung. If recurring attacks of fever and suppression of secretions persist, resection can be carried out easily and more safely after thoracoplasty has been tried.

On the whole subject one is not yet justified in being dogmatic. Certainly it is not yet closed. Experiment and trial are still in order and one would be bold to predict what will be accepted practice ten years from now. At the present time I am sure that due consideration for the individual patient will lead the individual physician to continue to use and try the older tested procedures and to reserve resection for those cases in which these have failed or are certain to fail.

DR. RICHARD H. SWEET, Boston, Mass.—I would like to point out that it was not my intention to enter the lists of controversy. I intended merely to make a presentation of facts. I am very much encouraged to see that Dr. Overholt's results are not much better than mine. I thought they might be very much better.

I would like to remind Dr. O'Brien that I did not say my results were good, although I would like to confess that they are better than I thought they would be.

DR. RICHARD H. OVERHOLT, Boston, Mass.—Surgeons are obligated to try to reduce the risk of operation for those patients who must have resection or else not get well. We did not mean to imply that we are using this operation routinely in preference to thoracoplasty. Approximately two out of three patients referred to us for resection are advised not to have a resection, but to have a thoracoplasty, or some other form of treatment instead.

This whole problem is not one involving competitive methods of treatment. Doctors all want to be conservative. We want to start with a given number of patients and have as many patients living and well at the end of a given period as possible. When patients run the gamut of all other forms of treatment, have had a thoracoplasty, or a cavernostomy, or something else, and still are sick and are going to die of the disease, why should one be criticized for attempting to salvage them?

There is always an opportunity for an honest difference of opinion as to whether a patient can be cured or not with thoracoplasty. If one knows that he will probably fail to cure a certain patient by thoracoplasty he should anticipate that failure before, not after, performing thoracoplasty. It is best to do the resection before the problem is complicated by other treatment failures. However, in the future possibly we will limit resection of the upper lobe to a fewer number than we have done in the past. In the questionable case, if there is any reasonable chance that thoracoplasty will suffice, it should be done. As pointed out repeatedly, resection should be restricted to those complicated cases of tuberculosis in which the patients do not have a chance to get well by any other method. I agree with everything Dr. Sweet and Dr. O'Brien have said in regard to bronchiectasis. Patients with asymptomatic bronchiectasis do not constitute an indication for resection. Patients should come to operation because they need it so that they may enjoy a better and a longer life.

TREATMENT OF CHRONIC SPONTANEOUS PNEUMOTHORAX BY LOBECTOMY

Report of a Case

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IT IS agreed generally that acute spontaneous pneumothorax responds well to treatment by conservative measures. These measures include rest in bed and aspiration of air from the pleural cavity when indicated by the development of symptoms due to increasing positive pressure within the pleural space. However, there is no general agreement at this time about the method of treatment that produces the best results in the occasional case of persistent or chronic spontaneous pneumothorax of nontuberculous origin. This, perhaps, is because of the infrequency with which this condition is encountered.

In consideration of the treatment of chronic spontaneous pneumothorax, several courses are available. A few cases are recorded in which lungs have remained collapsed for as long as seven and one-half years and ultimately have re-expanded.[1-4] Perhaps in an equal number of cases, re-expansion has failed to occur and the patients have had varying degrees of disability for years.[4, 5] Schomer and Ehrlich[6] have reported a case in which the lung failed to re-expand in more than five years. The woman was able to work in spite of moderate dyspnea and chronic cough. Bassel[7] has reported the case of a patient who probably had an unexpanded lung for seventeen years and who underwent a successful major surgical procedure, gastroenterostomy.

It is obvious, in spite of the few recorded cases in which patients have been able to get along and even do work not requiring too much exertion, that it is desirable to make efforts to re-expand the lung as soon, and in as safe a way, as is possible and is consistent with reliable results. A person who has one lung which is chronically unexpanded is subjected to the same limitation of activity and to the same hazards of respiratory infections as is a person with only one lung after pneumonectomy.

Re-expansion has been obtained in a number of cases by the introduction of irritating substances into the pleural cavity for the purpose of producing obliterative pleuritis.[4, 8-14] This method, however, is time consuming and often unreliable. The trend in recent years has been toward more direct measures aimed at the eradication of the bronchopleural fistula that is responsible for the maintenance of the pneumothorax. Such efforts have included cauterization of the mouth of the fistula through a thoracoscope; thoracotomy for direct visualization of the fistula and cautery to the mouth; and thoracotomy, resection of a small region surrounding the fistula, and closure of tissue with su-

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tures.[3, 11, 15, 16] In general, these methods of treatment have been more consistently successful than former methods. In our opinion, thoracotomy for exploratory purposes in cases of this kind is justified. The risk of thoracotomy today is minimal.

In the case which we are presenting, a thoracotomy was performed for exploratory purposes in the hope that the fistula could be closed by a minor procedure. It was thought advisable at the time of operation, however, to resect the entire middle lobe of the right lung. We have not found any other case recorded in the English literature in which lobectomy has been performed for chronic spontaneous pneumothorax.

CASE REPORT

A white man, 41 years of age, had a sudden attack of pain in the back and marked dyspnea, on Jan. 4, 1945. The pain and dyspnea developed during a mild attack of coughing. Because of continued symptoms, he consulted his physician, who made a diagnosis of spontaneous pneumothorax. Because of persistence of the pneumothorax, in spite of efforts to produce re-expansion, bronchoscopy was performed Feb. 1, 1945. This examination apparently revealed nothing of significance.

The pneumothorax was still present when the patient was first seen at the Mayo Clinic July 11, 1945. He had lost ten to fifteen pounds since January, 1945. Physical examination revealed an asthenic middle-aged man who was not in acute distress. A mass which was thought to be a small colloid goiter was found above the sternum. Examination of the thorax revealed a hyperresonant note on percussion and absence of breath sounds on the right side, with a shift of the mediastinal dullness to the left. The heart sounds were distant and there were no murmurs. The remainder of the physical examination gave essentially negative results.

Laboratory studies showed that the urine was normal. On examination of the blood, the level of hemoglobin was 16.7 Gm. per 100 c.c., leucocytes numbered 10,300 per cubic millimeter, and the sedimentation rate was 6 mm. in one hour. The flocculation test for syphilis was negative. Roentgenographic examination of the thorax July 11, 1945, showed tension pneumothorax on the right side with mediastinal herniation and shift of the heart and mediastinum to the left.

It was decided to hospitalize the patient for bronchoscopy and an effort was made to re-expand the lung by continuous suction applied to an intercostal cannula. Bronchoscopic examination gave negative results except for the findings to be expected in the presence of a collapsed lung. An S-shaped metal cannula was introduced through the eighth costal interspace in the midaxillary line and negative pressure was maintained for five days by means of water suction on the tap in the patient's room. Because roentgenologic examination gave evidence of only partial re-expansion after five days, the cannula was removed. Following this, the lung completely collapsed to its former position; this response indicated a persistent bronchopleural leak. It was decided that thoracotomy offered this patient the best chance of cure.

Penicillin in amounts of 120,000 units daily was given for four days preoperatively and thoracotomy was performed July 23, 1945. Through a right posterolateral incision, a long segment of the sixth rib was resected and the pleura was opened. There were multiple cysts in the middle lobe of the lung and there was an opening in one of these cysts which obviously was the site of the bronchopleural fistula. Because of the extensive involvement of the middle lobe by this cystic process, lobectomy seemed to be the most desirable procedure. This was carried out with dissection and individual ligation of the hilar structures. After removal of the middle lobe, both upper and lower lobes expanded satisfactorily so that they almost filled the right side of the thorax. The stump of the middle lobe was covered with pleura and the right pleural cavity was thoroughly washed with saline solution and with solution of zephiran chloride. Five grams of sulfanilamide were scattered around the

Fig. 1.—Right middle lobe showing emphysematous bullae and persistent bronchopleural fistula.

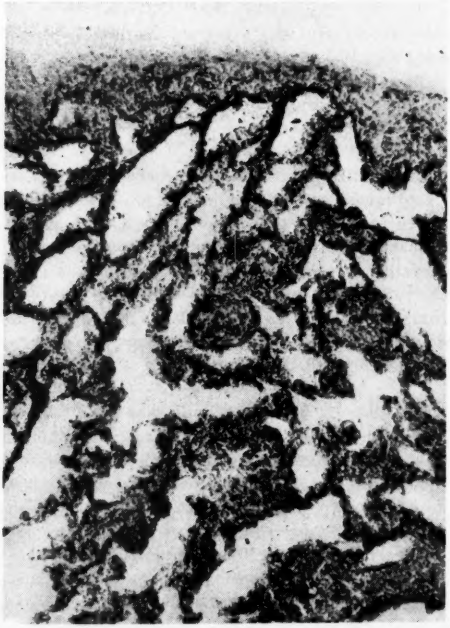

Fig. 2.—Edge of one of the bullae; note alveolar type of lining and tendency toward atelectasis in surrounding pulmonary tissue.

hilus. The thoracic wall was closed in layers. Two catheters were inserted, one in the fifth costal interspace in the anterior axillary line and another in the seventh costal interspace in the posterior axillary line, for the purpose of establishing closed drainage. Postoperative bronchoscopy was performed and a small amount of secretion was aspirated from the tracheobronchial tree.

The pathologist reported that the lobe contained multiple emphysematous bullae, the largest of which measured 3.5 cm. in diameter (Figs. 1 and 2). One of these blebs had ruptured into the pleural cavity and produced spontaneous pneumothorax.

The postoperative course was entirely uneventful. Administration of penicillin was continued for six days postoperatively. The temperature returned to normal on the fourth postoperative day and remained normal. The two intercostal catheters were removed on the fifth postoperative day. The patient sat up in a chair on the seventh postoperative day, was dismissed from the hospital on the thirteenth postoperative day and from the clinic on the seventeenth postoperative day. At the time of dismissal he was feeling well.

In a letter dated Nov. 15, 1945, approximately four months after the operation, the patient reported that he was feeling well, breathing without difficulty, and had gained sixteen pounds.

Of great interest to us is the fact that a bronchopleural fistula of this size and type can be present for such a protracted period without sufficient contamination to produce empyema or evidence of any significant inflammatory reaction of the pleural surfaces.

The extensive involvement by multiple emphysematous bullae of the middle lobe of the right lung, only, seemed to us to justify a procedure as extensive as lobectomy in this particular case because we were able to remove all involved tissue, leaving normal upper and lower lobes on the involved side.

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ROLE OF THE PULMONARY PLEXUS IN LUNG SURGERY

An Experimental Study

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ONE of the problems that frequently confronts the thoracic surgeon is the drop of the blood pressure during operations on the lung.

For a number of years some of these hypotensions were explained by the existence of a pleural reflex which, when stimulated would bring about a condition of shock. Later it was demonstrated that these so-called pleural shocks were due, not to an hypothetical nervous reflex but to air embolism. This contributed to explain some cases of shock during chest operations but it left unanswered the question of most of the sudden hypotensions that occurred.

Some observers noticed that this condition took place especially while the hilus was manipulated. It was thought since this region has a great number of nervous fibers which form the pulmonary plexus, probably the operative maneuvers gave rise to stimuli which by way of this plexus provoked reflex falls in blood pressure and other disturbances. Several authors have expressed their belief in this theory based on their surgical observations and have proposed the infiltration of the lung root with an anesthetic solution to block the onset of these reflexes. Subsequently, after applying this procedure they have reported that they no longer were hampered by brusque falls of blood pressure.

For a matter that has received so much attention on the part of chest surgeons, it is surprising that only a few experimental investigations have been carried out to prove the exactness of this clinical interpretation of the phenomenon.

In 1935 O'Shaughnessy reported that working on dogs he had stimulated the pulmonary plexus with an induction current. Drop of the blood pressure and apnea or difference in rate and character of the respiration were noted. He tried various procedures to prevent these cardiovascular and respiratory alterations and decided that the only adequate way to prevent this condition was to infiltrate the lung root with a 1 per cent solution of novocain. He concluded that the pulmonary plexus is an important sensory pathway and that it is important to prevent nociceptive impulses from passing through it. Bross and Lueken in 1938, experimenting on cats, obtained similar results with mechanical stimulation and also recommended local infiltration with an anesthetic solution.

It can be said then that this theory of the influence of the pulmonary plexus in the causation of cardiovascular disturbances is based on the clinical interpretation of what is seen on the operating table and supported mainly by the reports of O'Shaughnessy and of Bross and Lueken.

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The opinion of other surgeons, notably Graham, who deny any harmful effects of the pulmonary plexus during pulmonary resections, and the study of the course of a number of operations (all lobectomies or pneumonectomies) induced us to question the role of the pulmonary plexus as a source of hypotensive reflexes and suggested that these studies be repeated to see if similar results were obtained.

EXPERIMENTATION

Dogs were chosen for the test because they offer several advantages, mainly that the disposition of the pulmonary plexus is similar to that in man. This plexus is formed by sympathetic and parasympathetic efferent fibers. The former arise from the cervical and thoracic sympathetic trunk ganglia, the latter are preganglionic parasympathetic fibers of the vagus. The ganglionic cells are found in the plexus itself and in the intramural ganglia of the bronchial tree. Afferent fibers of both components of the autonomic system are also found and they follow the same pathways as the efferent nerves. The plexus is divided into two parts, one anterior and another posterior. They lie on the anterior or ventral and on the posterior or dorsal aspect of the lung root, respectively. The posterior plexus is by far the larger of the two.

Ether was used instead of nembutal or chloralose, which are commonly used as anesthetics in experimental work, since they may by themselves cause drops in the blood pressure. Intratracheal intubation was used in all cases and positive pressure was given by an artificial respiration machine, regulated in such a way as to obtain partial inflation of the lungs.

A cannula was inserted in the femoral artery and connected to an ordinary mercury manometer. Readings were taken by one of us at intervals of five minutes or less, as required.

The chest cavity was opened through a lateral incision with removal of the sixth or seventh rib. Careful hemostasis was made to avoid as much blood loss as possible and fluids were given intravenously during all the course of the procedure. Heparin and sodium citrate were used to prevent clots from obstructing the blood pressure readings.

Several groups of dogs were employed and in each of them a different procedure was used.

Group A.—In Group A the animals were kept under deep anesthesia (paralysis of the intercostal musculature) during all the course of the experiment. After the pleural cavity was opened the lung was gently retracted and the posterior aspect of the hilus visualized. A silk thread on a curved needle was passed under the fibers of the plexus trying to gather as many of them as possible. In dogs this is easy because the fibers of the posterior plexus are distinctly seen lying on the surface of the bronchus and of the pulmonary artery.

Now during five minutes a frequently interrupted pull was exerted on the silk thread. This was sufficiently forceful to cause a kink of the structures of the lung root but not so strong as to displace the whole mediastinum. The influence of this stimulation on the blood pressure is seen in Table I.

TABLE I. MECHANICAL STIMULATION OF THE PULMONARY PLEXUS OF DOGS UNDER DEEP ETHER ANESTHESIA

NUMBER	WEIGHT IN POUNDS	INITIAL B.P.	B.P. BEFORE OPENING PLEURAL CAVITY	B.P. BEFORE STIMULATION	B.P. AFTER STIMULATION	FIRST CONTROL AFTER 5 MIN.	SECOND CONTROL AFTER 10 MIN.	THIRD CONTROL AFTER 15 MIN.	FOURTH CONTROL AFTER 20 MIN.	DURATION OF PROCEDURE UP TO STIMULATION HR.	DURATION OF PROCEDURE UP TO STIMULATION MIN.	TOTAL DURATION OF PROCEDURE HR.	TOTAL DURATION OF PROCEDURE MIN.
1	27½	158	160	116	116	118	116	114	108	1	20	1	45
2*	20	100	106	76	76	74	72	72	64	1	35	2	
3†	21	130	104	80	96	78	90	80	86	1	25	1	50
4	16½	50	74	72	72	70	72	74	74	1	30	1	55
5	29	110	88	92	84	90	100	92	94	1	45	2	10
6	31	110	80	74	74	80	84	80	76	1	20	1	45

*In this dog, time was lost due to difficulties with the endotracheal tube.

†This dog was apparently very sensitive to the concentration of ether and it was seen that on increasing or decreasing it there was an immediate corresponding rise or fall in the blood pressure.

As it can be seen, there was no significant effect on the blood pressure. Readings were taken up to twenty minutes following the stimulation because it was felt that if no effect had been produced until then any change that might appear later could not be attributed to the stimulation.

The only significant drop in the blood pressure followed the opening of the pleura and we believe this was due to imperfect regulation of the positive pressure which permitted excessive inflation and deflation of the lungs and consequent shifting of the mediastinum. It will be seen that this did not occur in our later series when we had more experience with the management of our equipment.

Group B.—Although deep ether anesthesia causes only paresis of the vagus, some authors believe that this is sufficient to abolish the reflexes arising from the pulmonary hilus and therefore recommend that the plane of anesthesia be deepened during the handling of the lung root. Wishing to determine to what extent this assertion could be sustained experimentally we subjected a second series of dogs to the same procedure as those in Group A. After the silk thread had been passed around the nerve fibers, the anesthesia was lightened until the dogs showed eyeball activity and eyelid reflex. The results are tabulated in Table II.

TABLE II. MECHANICAL STIMULATION OF THE PULMONARY PLEXUS OF DOGS UNDER LIGHT ETHER ANESTHESIA

NUMBER	WEIGHT IN POUNDS	INITIAL B.P.	B.P. BEFORE OPENING PLEURAL CAVITY	B.P. BEFORE STIMULATION	B.P. AFTER STIMULATION	FIRST CONTROL AFTER 5 MIN.	SECOND CONTROL AFTER 10 MIN.	THIRD CONTROL AFTER 15 MIN.	FOURTH CONTROL AFTER 20 MIN.	DURATION OF PROCEDURE UP TO STIMULATION HR.	DURATION OF PROCEDURE UP TO STIMULATION MIN.	TOTAL DURATION OF PROCEDURE HR.	TOTAL DURATION OF PROCEDURE MIN.
1	23½	110	112	90	84	88	86	94	90	1	35	2	
2	39½	136	128	122	122	122	118	110	116	1	35	2	
3	29	160	128	146	156	152	140	136	144	1	15	1	40
4*	57½	134	120	114	114	106	100	100	100	2	20	2	45
5	51	164	168	120	126	126	126	126	126	1	10	1	35
6	30	150	132	132	126	132	134	130	130	1	5	1	30

*In this dog the total duration was almost three hours because of some difficulties with the blood pressure readings.

No appreciable modification in the blood pressure values were found, as can be noticed.

Group C.—To prove further that anesthesia plays no role in the blocking of these supposed hilar reflexes, a third series of dogs was submitted to the same procedure. This time, however, after passing the thread, the thoracic wall was carefully sutured and the anesthesia and intratracheal tube were removed. After waiting until the dogs had regained consciousness the same stimulation was repeated (see Table III).

TABLE III. MECHANICAL STIMULATION OF PULMONARY PLEXUS IN DOGS WITHOUT ANESTHESIA

NUMBER	WEIGHT IN POUNDS	INITIAL B.P.	B.P. BEFORE OPENING PLEURAL CAVITY	B.P. UPON COMPLETION	B.P. BEFORE STIMULATION	B.P. AFTER STIMULATION	FIRST CONTROL AFTER 5 MIN.	SECOND CONTROL AFTER 10 MIN.	THIRD CONTROL AFTER 15 MIN.	FOURTH CONTROL AFTER 20 MIN.	TOTAL DURATION OF ANESTHESIA		TOTAL DURATION FROM STARTING ANESTHESIA TO STIMULATION	
											HR.	MIN.	HR.	MIN.
1	13½	120	104	100	112	112	120	126	160	156	1	40	1	45
2	41	150	130	120	132	128	130	130	120	122	1	45	2	
3	19	148	120	120	120	120	120	120	120	120	1	35	1	43
4	24	120	116	116	104	120	110	110	112	114	1	50	1	55
5	21½	120	110	110	110	108	108	112	112	112	1	15	1	20
6	15½	70	112	108	110	110	110	116	116	116	1	10	1	15

During the excitation the animals gave some evidence of discomfort and tried to struggle free. Nevertheless (with the exception of Dog 1, in which it went up), the blood pressure remained even more stable than in the former experiments.

Group D.—Up to this time we had used pulling a thread passed around the fibers of the plexus as a means of stimulation. We felt that this was what most nearly resembled the pulling and stretching which usually takes place during difficult dissections of a lung root stuck by inflammatory adhesions, metastasized glands, and so forth. As it could be argued that perhaps these dogs had failed to react and show significant blood pressure drops due to inadequacy of the stimulus we proceeded to repeat O'Shaughnessy's experiment in six other dogs, using an induction coil at 11 cm. distance as electrical excitant. The anesthesia was kept at the same level as in Group B (observe Table IV).

As can be seen in opposition to O'Shaughnessy's findings, the electrical stimulation of the plexus failed to produce any changes in the blood pressure. With these results we felt justified in concluding that, at least in the experimntal animal, mechanical or electrical stimulation of the pulmonary plexus caused no visible alteration of the blood pressure. The respiratory response, if any, could not be detected as the dogs were given artificial respiration with an automatic machine.

We then tried to discover whether or not other stimulations or trauma inflicted on the lung or its root, the phrenic or the vagus nerve, would cause the fall in the blood pressure which the excitation of the pulmonary plexus had failed to produce.

TABLE IV. ELECTRICAL STIMULATION WITH INDUCED CURRENT IN DOGS UNDER LIGHT ETHER ANESTHESIA

NUMBER	WEIGHT IN POUNDS	INITIAL B.P.	B.P. BEFORE OPENING PLEURAL CAVITY	B.P. BEFORE STIMULATION	B.P. AFTER STIMULATION	FIRST CONTROL AFTER 5 MIN.	SECOND CONTROL AFTER 10 MIN.	THIRD CONTROL AFTER 15 MIN.	FOURTH CONTROL AFTER '20 MIN.	DURATION OF PROCEDURE UP TO ELECTRICAL STIMULATION		TOTAL DURATION OF PROCEDURE	
										HR.	MIN.	HR.	MIN.
1*	56	140	106	96	102	100	98	98	98	1	55	2	20
2	24½	140	134	136	138	136	132	130	130	1	20	1	45
3	25	116	96	96	96	96	90	92	90	1	25	1	50
4	19	116	116	138	126	126	126	126	126	1	5	1	30
5	29	82	86	90	92	90	84	86	86	1	25	1	50
6	41½	142	126	134	130	130	130	128	130	1	20	1	45

*In this dog the intratracheal tube had to be changed.

Both the phrenic and the vagus were severed, the latter above and below the point where it branches to the pulmonary plexus. The lung proper was crushed with a Kelly forceps; the lung root was also crushed all at once and each element separately. None of these maneuvers repeated several times produced a fall in blood pressure. Finally the lung root was caught by passing two fingers around it and the lung was pulled almost entirely out of the chest cavity. This caused a pronounced displacement of the entire mediastinum. It was then seen that the blood pressure began to fall rapidly and became stabilized at a level much lower than before. The lung was then released and an instantaneous elevation to near the previous level occurred. In the subsequent three to five minutes the blood pressure regained its previous figure.

Group E.—As this was the first procedure that succeeded in influencing the blood pressure in a marked way, we decided to repeat it in another group of dogs to see if the results were constant. In each case the lung was pulled out during ten seconds and released for about fifty or sixty seconds. This was done for a period of five minutes (see Table V).

The results were uniform as can be observed. In all of the cases the blood pressure dropped gradually in about ten to fifteen seconds and when the lung was allowed to fall back into the chest the blood pressure rose in two to three seconds to near the previous level, without reaching it entirely, however.

The gradual fall of the blood pressure and the almost instantaneous recovery which could be reproduced three or four times in the short period of five minutes caused us to believe that probably no nervous mechanism was involved. In any event, the displacement of the mediastinum perhaps could have stimulated well-known reflex centers, therefore we tried to exclude the pleural plexus from being one of them.

Group F.—A second group of dogs was investigated. The procedure was the same as in Group E, but before tractioning, the hilus was infiltrated with 1 per cent percaine in Dogs 1, 2, and 3 and 1 per cent novocain in Dogs 4, 5, and 6 (see Table VI).

TABLE V. TRACTION OF PULMONARY ROOT WITH SHIFTING OF MEDIASTINUM IN DOGS UNDER DEEP ETHER ANESTHESIA

NUMBER	WEIGHT IN POUNDS	INITIAL B.P.	B.P. BEFORE OPENING PLEURA	FIRST TRACTION	SECOND TRACTION	THIRD TRACTION	FOURTH TRACTION	FIRST CONTROL AFTER 5 MIN.	SECOND CONTROL AFTER 10 MIN.	THIRD CONTROL AFTER 15 MIN.	FOURTH CONTROL AFTER 20 MIN.	DURATION OF PROCEDURE UP TO FIRST TRACTION		TOTAL DURATION OF PROCEDURE	
												HR.	MIN.	HR.	MIN.
1*	26	120	112	104	—	—	70	100	100	90	84	1	15	1	45
2	36	120	100	110-70	80-60	72-60	74-62	85	86	88	88	1	20	1	45
3	26	126	130	130-110	128-110	128-98	128-96	120	128	130	130	1	15	1	40
4	39	104	122	122-82	94-78	96-78	—	104	102	104	106		53	1	20
5	20	100	112	100-76	92-74	96-76	—	100	96	100	108		53	1	20
6†	32½	120	120	116-90	110-96	114-86	114-86	112	104	100	100	1	45	2	5

*In this case a continuous traction was exerted during the entire five-minute period.
†In this dog difficulties with the blood pressure readings prolonged the procedure.

TABLE VI. TRACTION OF PULMONARY ROOT WITH SHIFTING OF MEDIASTINUM IN DOGS UNDER DEEP ETHER ANESTHESIA AND LOCAL INFILTRATION WITH 1 PER CENT NOVOCAIN

NUMBER	WEIGHT IN POUNDS	INITIAL B.P.	B.P. BEFORE OPENING PLEURAL CAVITY	TRACTIONS			FIRST CONTROL AFTER 5 MIN.	SECOND CONTROL AFTER 10 MIN.	THIRD CONTROL AFTER 15 MIN.	FOURTH CONTROL AFTER 20 MIN.	DURATION OF PROCEDURE UNTIL TRACTION		TOTAL DURATION OF PROCEDURE	
											HR.	MIN.	HR.	MIN.
1	33	122	120	96-80	94-80	96-62	66	72	76	76	1	50	2	15
2	31½	86	96	96-76	96-74	86-70	88	88	92	90	1	20	1	45
3	45	142	122	110-70	102-72	98-70	122	120	114	114	1	42	2	7
4	30½	136	130	130-100	124-96	120-92	118	114	118	122	1	25	1	50
5	34	134	136	116-86	106-84	110-78	120	122	120	120	1	30	1	55
6	24½	86	84	76-62	72-60	70-60	66	66	68	68	1	15	1	40

It is evident that the infiltration made no difference and the blood pressure in these cases dropped exactly in the same way as in the previous series.

This, in our opinion, served to prove that when a stimulation had eventually succeeded in causing a drop in the blood pressure the pleural plexus played no role in its onset and the infiltration of the lung root would therefore make no difference.

SUMMARY

1. The results of an experimental study of the role of the pleural plexus in the causation of sudden blood pressure drops during intrathoracic operations are reported.

2. Thirty-six dogs divided into six groups were used for this study.

3. In the first three groups the pleural plexus was stimulated mechanically by pulling the nerve fibers by means of a silk thread passed around them. This was done in Groups 1 and 2 under deep and light ether anesthesia, respectively. In the third group it was done without anesthesia.

4. The fourth group was stimulated with an electrical current from an induction coil at a distance of 11 cm.

5. In none of these dogs did the mechanical or electrical excitation produce any significant alteration of the blood pressure either immediately after or during the following twenty minutes.

6. In the fifth group of dogs the manual exteriorization of the lung from the chest cavity with marked displacement of the mediastinum caused immediate and pronounced drop of the blood pressure.

7. Infiltration of the hilus with an anesthetic solution failed in the sixth group to prevent a fall of blood pressure when the dogs were submitted to the same procedure as those of Group 5.

CONCLUSIONS

1. Based on the results of this experimental study, the authors conclude that in opposition to O'Shaughnessy's findings, they find that the pulmonary plexus does not play any role in the onset of sudden hypotension during intrathoracic operations.

2. The infiltration of the hilus with an anesthetic solution is not necessary.

3. Shifting of the mediastinum with stimulation of well-recognized reflex centers such as the arch of the aorta may have some influence in producing modifications in the blood pressure.

4. The study of the results obtained in Groups 5 and 6 leads the authors to think that the alterations of blood pressure are due to mechanical impediment of the blood flow into the heart. Such procedures as packing the pleural cavity or excessive pulling during difficult dissections likewise can produce kinking or compression of the great veins and consequently hypotension.

5. Further studies are required to elucidate which of the two latter mechanisms play a more important role.

The authors wish to acknowledge their gratefulness to Dr. E. A. Graham for placing at their disposal all necessary elements in order to carry out this investigation at the Surgical Department of Washington University.

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THE TREATMENT OF THORACIC ACTINOMYCOSIS BY PENICILLIN AND SULFONAMIDE DRUGS

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WHILE actinomycosis (streptothricosis and nocardiasis) is the commonest of systemic mycoses, nevertheless, it remains a comparatively rare disease. It has a world-wide distribution and is general in the United States, although certain localities such as the midwest and northwest farming districts are reputed to have a relatively higher incidence. In western Pennsylvania, centering around Pittsburgh, the cases are infrequent. I have been able to find in the files of thirty hospitals records of only sixteen primary cases, distributed as follows: eight abdominal, one cervicofacial, seven thoracic. Eleven of these were known to have had a fatal outcome. Observers usually state that primary invasion of the lungs and thorax occurs only in 15 per cent of cases as compared with 60 per cent in the cervicofacial region and 20 per cent in the abdomen. Three of the patients with thoracic invasion have been under my care at the Presbyterian Hospital. Their histories follow.

CASE REPORTS

Case 1.—*Primary Actinomycosis in Pleura and Lung.*—C. M., aged 59 years, married, was a plumber. On May 18, 1945, he became acutely ill with pain in the left lower part of the chest; he had a slight nonproductive cough and temperature of 101 to 103° F. White blood count was 14,200; polymorphonuclear cells, 78 per cent; hemoglobin, 80 per cent; red blood count, 3,000,000. The family physician treated him for acute pleurisy and pneumonitis with sulfadiazine, 60 gr. a day for three weeks. Then the fever subsided. Signs of fluid at the base of the left lung persisted. Four ounces of slightly turbid sterile fluid were removed. It was suspected that the condition might be tuberculous pleurisy. Two guinea pigs were injected but did not develop any infection. In the first week of July fever and cough recurred, and sputum instead of being small in amount and white became more copious and yellowish. He lost weight and strength perceptibly. He was treated with penicillin intramuscularly, receiving 500,000 units in July and 750,000 units in August. About September 1 exploration again of the pleura at the base of the left lung secured a small amount of sterile albuminous fluid. September 9 he was admitted to the Presbyterian Hospital. The chief complaint was pain in the lower left costal area anterolaterally of a dull aching character with some superimposed knifelike exacerbations which radiated into the left arm. Cough was slight with small amount of whitish sputum. Red blood count was 3,800,000; hemoglobin, 70 per cent; white blood count, 14,800; polymorphonuclears, 78 per cent. Temperature ranged from 99 to 102° F., pulse from 80 to 100, respirations from 20 to 24. X-ray examination at this time suggested the presence of fluid at the base of the left lung with possible underlying pneumonitis or abscess. Aspirating needle through the eighth interspace in the scapular line at a depth of about two inches entered an abscess which contained somewhat odorous yellowish-green pus containing small yellowish granular material. This proved to be sulfur granules of actinomycosis on smear, but did not grow on culture.

Bronchoscopy on September 11 discovered no abnormality. There was some mucus found in the bronchial tree of the left lung but no pus. On September 14, under local

Read (by title) at the Twenty-sixth Annual Meeting of The American Association for Thoracic Surgery, Detroit, Mich., May 29, 30, and 31, 1946.

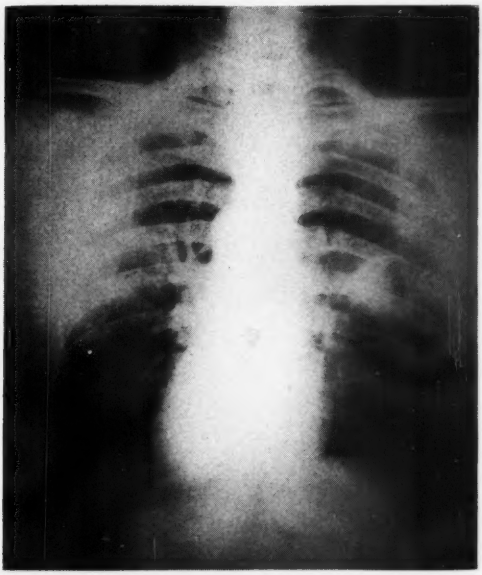

Fig. 1.—May 19, 1945, an area of consolidation in the upper part of the right lower lobe suggestive of pneumonitis; slight evidence of pleuritis at the base of the left lung.

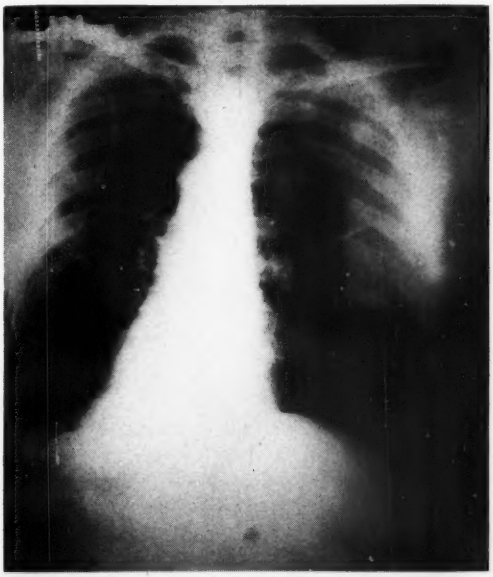

Fig. 2.—July 13, small amount of fluid in the costophrenic sinus; small area of consolidation in left lobe above the diaphragm, a fibrous band along the right interlobar fissure.

Fig. 3.—September 7, consolidation at the base of left lung, suggestion of encysted fluid in adjacent pleura.

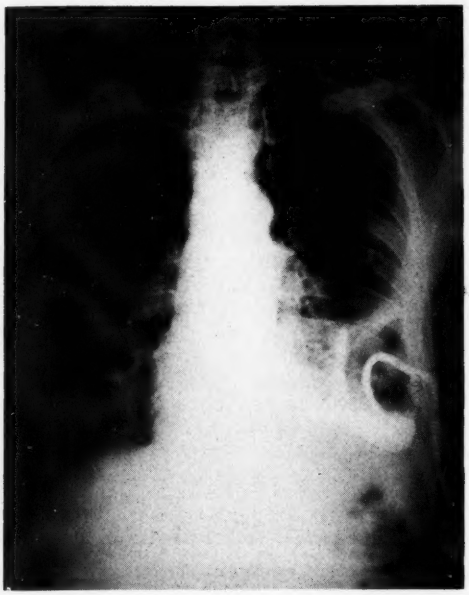

Fig. 4.—September 27, cavity present in the left lower lobe laterally, measuring 2½ inches by 4 inches with considerable fibrosis in the lung.

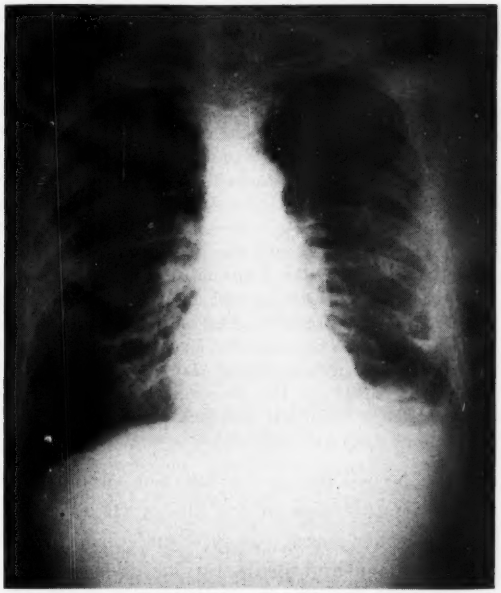

Fig. 5.—November 8, small cavity with small lipiodol residue; obliterated costophrenic sinus and thickened pleura.

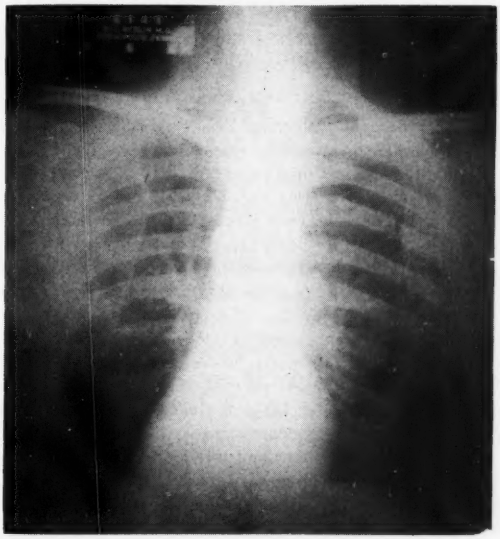

Fig. 6.—May 8, 1946, scar of obliterated cavity in lung, trace of lipiodol still present; costophrenic sinus clearing.

anesthesia, a No. 16 catheter was inserted into an abscess of the lower lobe of the left lung. This cavity was washed out with salt solution and 25,000 units of penicillin were instilled every six hours. No actinomycoses were found in smears or culture after September 20. October 3 Wangensteen suction was applied, the cavity having a capacity at that time of 40 c.c. On October 13 the catheter was removed when the abscess cavity had a capacity of about 10 c.c. and the purulent discharge had ceased. October 18 the patient was discharged home in the care of his family physician, feeling well and free from symptoms except for some pain still in the region of the ninth and tenth ribs in the left anterior axillary line. During the hospital stay he had a total dosage of penicillin intramuscularly of 3,825,000 units and by instillation in the abscess of 3,150,000 units. He continued to feel well, except for the pain, until the first week in January when a small swelling appeared at the site of the pain in the left lower part of the chest. Penicillin was reinstituted. From January 9 to 18 he had 50,000 units every four hours intramuscularly, and January 24 to February 18, 50,000 units every three hours. There was no appreciable effect on the swelling so this was incised and yellow thick pus was obtained in small amount. Exploration of the abscess cavity failed to find any extension to the ribs or pleura. Smear and culture showed *Staphylococcus aureus* but no actinomyces. With drainage of this abscess, pain subsided immediately. The abscess has since healed and there is no clinical manifestation of disease in the chest. On April 1, 1946, he resumed his usual work and activities.

Discussion.—The diagnosis in this case was not established until about three and one-half months after the onset of the illness when pus was obtained from the left lung showing actinomycoses, the type undetermined. This abscess was treated with closed drainage and penicillin instillations in conjunction with penicillin intramuscularly. The total amount of penicillin used in the treatment of the case over eight months was approximately 15,000,000 units. It is believed that now the lung is healed and that actinomycosis has been eradicated, however, it is too early to state that the patient is permanently well. Presumably this cannot be alleged until another year or eighteen months have elapsed.

CASE 2.—*Primary Pleural Actinomycosis, Trichinosis.* S. W., a woman aged 34 years, on December, 1941, following an operation to suspend a kidney, developed an empyema for which there was done a rib resection in January, 1942. A draining sinus persisted. She was admitted to the Presbyterian Hospital Feb. 22, 1943. X-ray examination suggested an interlobar empyema with markedly thickened pleura. A thoracotomy was done February 25. A 2 cm. thick pleura was found but no fluid. Smear and culture of the tissue were negative for bacteria. Pathologic examination of section of the pleura and of the diaphragm showed chronic pleuritis with encysted larvae of *Trichina spiralis;* a biopsy of the pectoral muscle confirmed this finding of trichinosis. In May the patient developed an abscess in the lower right part of the neck. Subsequent abscesses developed in the right lumbar region, beneath the left scapula, in the left thigh posteriorly, above the left knee, and in the left lumbar region. The organism was always *Staph. aureus.* The patient died on December 6. At autopsy actinomycosis was discovered for the first time. The lungs were extensively invaded, but at no time had actinomycosis been demonstrated in any of the abscesses or pleura or sputum and it was not suspected. The liver and left kidney also had actinomycotic abscesses. The diagnosis had been staphylococcic bacteriemia superimposed on trichinosis. In the course of the illness the patient was given massive doses of sulfonamide drugs without benefit and apparently without any curative influence upon the actinomycosis.

CASE 3.—*Primary Actinomycosis of Liver and Kidney, secondary in the lung.* T. S., a man aged 52 years, became ill in January, 1938, with a cold and flare-up of what he considered old sinusitis. A tooth was extracted and following this he had a chill with high temperature and became quite toxic; about February 1 he developed an intense icterus. There

was enlargement of the liver with considerable tenderness. X-ray appearance suggested the presence of a subhepatic abscess and also an enlargement of the right kidney. He was admitted to St. Francis Hospital. March 19 an exploratory puncture secured rather thick pus through the eleventh right interspace and presumably from the liver itself. Organisms found were *Staph. aureus* and *Aspergillus glaucus*. The abscess was drained and found to be both subhepatic and intrahepatic. The patient improved progressively, but a sinus persisted draining staphylococcic pus. On this account he was admitted to the Presbyterian Hospital August 10, with a suspicion of having a perinephritic abscess. Exploration August 10 discovered that the swelling was a large kidney. No extrarenal abscess was found. A biopsy of the liver established a diagnosis of pericholangitis and fatty degeneration. Further study determined a polycystic largely nonfunctioning kidney. Culture of the urine was negative. September 9 a nephrectomy was done and the kidney was found to be almost completely destroyed by actinomycosis. The operation wound healed fairly well but the patient failed progressively and died on November 17. Autopsy discovered multiple abscesses of actinomycosis in both lungs with metastatic spread to the meninges, an acute and chronic glomerulonephritis of the left kidney, and septic spleen.

This case presumably had been a primary actinomycosis in the right kidney or liver with later metastatic spread to both lungs, and to the meninges as a terminal event. At no time were there symptoms pointing definitely to lung involvement. A number of sputum examinations failed to demonstrate any fungus. Following the discovery of actinomycosis of the kidney he was placed on large doses of iodides without benefit.

There has been some confusion and uncertainty in the classification of actinomycoses. For the purpose of clinical teaching in the war two types have been recognized as pathogenic and productive of disease in man.

1. *Actinomyces bovis:* An anerobic form, gram positive, and nonacid fast.

2. *Nocardia asteroides:* An aerobic acid-fast group which includes *Nocardia gypsoides*. An aerobic nonacid-fast group is called *Nocardia madurae*. Both types produce mycelia which form tangled masses of filaments, recognized as "sulfur granules."

Characteristically these fungi produce a chronic granulomatous type of inflammation in which suppuration, abscesses, and sinuses develop, and dense scar tissue is produced in excess. The inflammation burrows through tissue with little or no respect for normal fascial planes and anatomic barriers. The dense fibrous tissue diminishes vascularity and therefore renders the lesions less permeable to the action of drugs. Superimposed upon the actinomycotic process there is often secondary infection due to pyogenic bacteria.

Infection of the lung may be air-borne or from fungi aspirated from the mouth, teeth, and tonsils. Three types of thoracic disease are differentiated but are really all part of one process:

1. *Bronchitic,* where invasion most frequently starts in the bronchi, but rarely stays confined to the bronchial tree.

2. *Pneumonic,* a bronchopneumonitis where the parenchyma of the lung is replaced by nodular or not infrequently diffuse caseating infiltration which breaks down into small or larger abscesses. The usual location is in the lower or central portions of the lungs.

3. *Pleuritic,* where the invasion is most extensive in the pleura. Pleural thickening even to the extent of 2 or 3 cm. is not uncommon. From these pri-

mary locations the disease spreads to involve ultimately the chest wall. Abscesses form anywhere, but commonly near the breast and axilla, and then sinuses develop. Ribs are invaded in 25 per cent of the cases, vertebrae in 10 per cent, the sternum occasionally. Rarely the heart, pericardium, and esophagus are involved.

Clinical symptoms are initiated quite consistently with a cough, at first dry and unproductive, and then with mucoid sputum which later becomes purulent and streaked with blood. Frank hemorrhage is rare. Intermittent fever, dyspnea and malaise, night sweats, loss of weight ensue. Pain develops when the pleura is involved. The patient lapses, if he survives the acute phase, into a chronic state, and untreated, dies of asthenia, of secondary infection, or of amyloid visceral disease. There is not a characteristic blood picture but secondary anemia and high leucocytosis are usual. White blood cells may range as high as 44,000. Physical signs depend upon the amount and character of pulmonary and pleural involvement. The clinical picture is quite suggestive of pulmonary tuberculosis.

X-ray appearance varies considerably with the age of the disease. At first there is hilar and peribronchial infiltration. Then small or larger areas of consolidation appear, with abscess formation, massive thickening of the pleura, or collections of pleural effusion particularly over the lower lobes of the lung. The picture is not distinctive, so the diagnosis of actinomycosis cannot be made by x-ray. However, marked pleural thickening, erosion of ribs, contracture of the chest wall, and narrowing of the pulmonary field are quite suggestive.

Diagnosis of thoracic actinomycosis is not easy to make, particularly in the early stages. This is unfortunate since successful treatment goes hand in hand with early treatment. Quite often the disease is not suspected while the patient is under treatment, as happened in two of my cases, until the terminal stages of the illness, or autopsy is performed. It is established definitely by finding characteristic mycelia or "sulfur granules" in pus or fixed sections of tissue. However, at times these are not present. The differential diagnosis must be made from tuberculosis which the disease resembles quite strongly clinically, from pyogenic abscess, and bronchiectasis and empyema due to pyogenic bacteria.

TREATMENT

Iodides.—For years iodides and iodine in the form of Lugol's solution were the drugs of choice in the treatment of actinomycosis. *X-ray radiation* was often used in addition or alone. For the most part this treatment did not affect the course of the disease materially nor favorably and thoracic cases were almost universally fatal.

Surgery has always been recognized as essential to successful treatment, as Wangensteen and Bisgard have emphasized. Abscesses should be drained, sinuses of the chest wall excised, diseased portions of ribs removed, and often involved portions of the lung ablated. It would seem that the major factor in arresting the disease prior to the last decade was surgery.

Thymol.—In 1927 Myers[10] introduced thymol and reported four recoveries in cervicofacial disease. One patient with pulmonary involvement died but a

second was substantially improved. Etter[11] reported a patient with pulmonary involvement recovered after thymol treatment and well five years later. Moseley also recorded favorable outcome after massive excision of the chest wall and packing with thymol. However, in four other reported cases of thoracic disease the results were not favorable.

Sulfonamide Drugs.—In the last decade sulfonamide drugs have come into vogue. In general the outcome has been much better than with any prior treatment. In some cases where other methods failed sulfonamide drugs were used successfully and given credit for recovery. Sulfonamide drugs may exercise favorable influence because of their effect on secondary pyogenic infection. In many cases, however, an early dramatic favorable response to sulfonamide drugs was not maintained. We have found records of fifteen nonthoracic cases where sulfonamide drugs were the major treatment and ten patients responded favorably. In thirteen cases of thoracic disease five patients apparently recovered and were well for periods of from six months to two years. In seven of these cases iodides previously administered failed to help and in one case surgery had been unavailing.

Penicillin.—In the last three years penicillin has come into extensive use. Reports of nonthoracic cases with treatment by penicillin, thirty-six in number, have shown that thirteen patients were well, seventeen markedly improved but not considered recovered because of the short time elapsing after treatment ceased, four improved, and two dead. There are fifteen cases reported of treatment in thoracic actinomycosis (see Table I). Of these, twelve patients are well, two improved, and one dead. In several of these recoveries it is to be noted that pencillin was given only as a last resort in the terminal stage of the disease. Of these fifteen cases, four patients had sulfonamide drugs in conjunction with penicillin, and eight had surgery so that the favorable outcome should probably not be ascribed wholly to the penicillin. The difficulty in assaying the worth of penicillin at this time comes from the meagerness of follow-up observation and from the fact that in most reports only a few weeks or months, at most two years, have elapsed since the treatment was stopped. In the light of the propensity of the fungus to stay latent for long periods and then break out with a new lesion, one should not feel that recovery has taken place unless the patient is symptom free for at least eighteen months. In the administration of penicillin for thoracic actinomycosis it would seem that the following plan of treatment will be successful:

1. Large doses of 100,000 to 200,000 units a day for a period of ten to fourteen days. It should be noted that the sensitivity of actinomycoses varies as does that of pyogenic bacteria to penicillin. Some strains are fairly insusceptible. A plate test or broth culture reaction may be the proper guide for dosage.

2. A recurrent course of treatment after several weeks' rest, and these subsequent treatments to last over a twelve months' time or to be given at any time that symptoms of the disease reappear.

3. Intramuscular administration is the route of choice but this may be combined with intrapleural or intrapulmonary injection as in our own case.

TABLE I. THORACIC ACTINOMYCOSIS TREATED BY PENICILLIN

CASE	AUTHOR	AGE SEX	DURATION OF SYMPTOMS	STRUCTURES INVOLVED	PRIMARY OR SECONDARY	DOSAGE OF PENICILLIN	ACCESSORY TREATMENT	RESULTS*		
								WELL	IMPROVED	DIED
1	Poppe[1]	19, F	3 yr.	Lung, chest wall, pleura	P	2,000,000 U. for 2 wk.; later 2,000,000 U.	Pneumonotomies, lobectomy, cautery-lobectomy	1 yr.		
2	Poppe	49, M	19 mo.	Lung, chest wall, pleura	P	2,000,000 U. for 2 wk.	Lobectomy	1 yr.		
3	Poppe	46, F	5 yr.	Lung, chest wall, pleura	P	Repeated courses 8,340,000 U. in 5 mo.	Pneumonotomies, Lobectomy, thoracoplasty, thoracotomies	1 yr.		
4	Dobson and Cutting[2]	56, M		Lung, chest wall	P	4,500,000 U. in 3 wk.		1 mo.		
5	Dobson and Cutting	39, M	14 mo.	Lung, chest wall	P	5,000,000 U. in 11 wk.	Drainage, empyema	1 mo.		
6	Christie and Garrod[3]			Lung, chest wall	P	700,000 U. in 7 days				1 wk. pyocyaneic septicemia
7	Jones and Brownell[4]	44, F	16 mo.	Chest wall	S to pelvic hysterectomy	2,000,000 U. in 30 days; sinus irrigated by 5% solution 4 times daily		X† Sinuses closed		
8	Jones and Brownell	44, F	12 mo.	Chest wall	S to pelvic hysterectomy	4,000,000 U.; sinus irrigated by 5% solution 4 times a day		X Sinuses closed		

9	Arden[5]	10		Chest wall, fifth and sixth ribs		1,200,000 U. daily cavity irrigation with penicillin 15 days		6 wk.	
10	Kay and Meade[6]			Lung	P	Not stated	Sulfonamide drugs, pulmonary resection	X	
11	Kay and Meade			Lung	P	Not stated	Sulfonamide drugs, pulmonary resection	X	
12	Harrell[7]			Lung, pleura	P	Not stated		X	
13	Roberts[8]	22	2 mo.	Lung, pleura, chest wall, subphrenic abscess	P	First course 14 days 1,800,000 U.; 2nd Course 28 days 5,000,000 U.	Sulfonamide drugs, surgical drainage, abscesses	X	
14	Decker	57	4 mo.	Lung, pleura	P	15,000,000 U. intramuscularly and by cavity irrigation	Aspiration and surgical drainage, abscesses	X 2 mo.	
15	Sheppard[9]	46	2 mo.	Pleura, chest wall	P	5,000,000 U.	Sulfonamide 160 gr. before penicillin		X 6 wk.

*Summary

	Penicillin	*Sulfonamide Drugs*
Well	12	5
Improved	2	3
Unimproved	0	2
Died	1	3

†X, well at close of treatment.

4. Early administration. This, of course, is corollary to the early recognition of the disease and will secure the best results.

5. Sulfonamide drugs in addition to penicillin are not contraindicated and may help to take care of any associated pyogenic infection.

6. Surgery is always an important adjunct to treatment. In three cases recently reported by Poppe, extensive surgery was done including lobectomy and pneumonectomy when drainage of the lung did not suffice.

CONCLUSIONS

It would seem that penicillin is the number one therapeutic agent for thoracic actinomycosis as well as actinomycosis is anywhere in the body. If administered early it will consistently cause arrest of the disease and recovery in any age group. In most cases it will bring favorable outcome even though the disease is of long standing and when other drugs have failed. There is no contraindication to the use concomitantly of sulfonamide drugs, which may be extremely helpful in clearing secondary pyogenic infection. Surgery will often be needed to assure a good result or to shorten the course of treatment.

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In Memoriam

Within the year two pioneer and eminent thoracic surgeons passed away; both of whom were original members of the editorial board of the JOURNAL and later presidents of the American Association for Thoracic Surgery. These men were Edward William Archibald of Montreal and Howard Lillienthal of New York. Both were very important figures in the development of thoracic surgery to its present state. It is significant that both were exceptionally able general surgeons before entering the field of thoracic surgery.

The editor has undertaken to write an appreciation of Dr. Archibald and has asked Dr. Harold Neuhof, one of Dr. Lilienthal's most distinguished and most beloved pupils, to write the obituary notice of Dr. Lilienthal.

EDWARD WILLIAM ARCHIBALD

1872-1945

On Dec. 17, 1945, at the age of 73 years, the brilliant and influential career of Edward William Archibald came to an end. Although his life was spent in Montreal where he was at first a student and later professor of surgery at McGill University and physician-in-chief of the Royal Victoria Hospital, he was well known personally throughout Europe, the British Empire, and particularly in the United States. Perhaps no surgeon had so many friends among his colleagues throughout the world as he had. He combined so great a warmth and personal attractiveness that he was always welcome at any gathering of surgeons. Part of his personal charm was his delicate sense of humor and his ability to criticize in a humorous way without giving offense. The fact that he was distressingly absent-minded served to endear him the more to his friends. He seldom missed a meeting of The American Association for Thoracic Surgery or of the American Surgical Association where he always found his friends on this side of the border eager to see him.

Archibald's nature was that of the explorer and pioneer. At a time when the surgeons of North America were but little interested in pathology he became an expert pathologist and likewise developed an experimental approach to the study of disease processes. He was one of the first, if not actually the first, surgeons on this continent to operate for pulmonary tuberculosis, and his early work helped greatly in the development of the modern surgical treatment of that disease. Another important contribution was his description of what he termed, for want of a better name, "oedema of the pancreas," a condition now well recognized and generally called interstitial pancreatitis. Moreover, he was one of the first to recognize the important role played by bile in the development of acute pancreatic necrosis.

One of Archibald's greatest interests was the education of the surgeon, primarily in order to protect the public from the incapable surgeon. In his presidential address in 1935 before The American Surgical Association, entitled "Higher Degrees in the Profession of Surgery," he emphasized the need of an examining body of some sort for the purpose of qualifying surgeons. The idea was immediately approved with the result that The American Board of Surgery was created. It was he who appointed on that board the first representatives from The American Surgical Association.

Edward William Archibald
1872-1945

He received many honors of which only a few will be mentioned. In 1936 he received the Trudeau medal of the National Tuberculosis Association and in 1937 the Bigelow medal of the Boston Surgical Society. He was also an honorary Fellow of the Royal College of Surgeons of England and of that of Australasia. Several European surgical societies honored him by making him a corresponding member.

Evarts A. Graham

Howard Lilienthal

1861-1946

When Howard Lilienthal passed away on April 30, 1946, in his 85th year there disappeared from the scene one of the few remaining great American pioneers in surgery. He belongs to that famous group which created the setting

for the present-day pre-eminence of American Surgery. He may be said to be virtually unique amongst them in the variety of surgical conditions to which he set his pioneering thoughts and hands. Some 300 contributions to medical literature bearing for the most part original thoughts couched in crystal-clear language, as well as new operative procedures or variations of those already proposed, provide written evidence of the many fields which he entered.

Howard Lilienthal
1861-1946

Some reference to the directions in which Dr. Lilienthal pioneered before he devoted himself to thoracic surgery reveals the breadth of his interests. His very first paper, published in 1892, four years after he entered practice, laid down methods for dealing with severed tendons and nerves at the wrist. Not long after (1896) there was a contribution describing an osteoplastic flap for a tibial defect. The roentgenogram illustrating the operative result represents one of the earliest demonstrations of the application of x-rays for such purposes. About the same time he employed films inserted into the mouth for the diagnosis of a tumor of the superior maxillae, a method in universal practice today but not developed at that time. In 1902 there was the first of a series of papers on suprapubic prostatectomy. It is of historic interest to note that Dr. Lilienthal appeared to be the first to advocate and practice the two-stage operation. He was also amongst the first to employ a two-stage operation for duodenal and gastric ulcer, whenever a primary gastrectomy appeared too formidable a

procedure. Indeed, he was always an ardent advocate of two-stage operations under special circumstances on the twin principles of reducing the mortality of operation and permitting infection or obstruction to subside. Thus, in addition to being one of the earliest champions of primary cholecystectomy in appropriate cases (his first cholecystectomy was reported in 1896) he was amongst the first to advise and practice a two-stage operation if the presence of severe infection was thought to jeopardize too greatly the chances for recovery after a primary cholecystectomy. This same constructive approach was conceived for intra-abdominal tumors and inflammatory masses producing obstruction. An example from that early period was a case of an enormous fixed mass in the right lower quadrant encountered at an exploratory laparotomy. A side-tracking anastomosis was made. Several weeks later the mass, greatly reduced in size, could be removed with impunity. The thought of drainage of a pulmonary abscess before resorting to more radical operations was along the same lines. It is therefore evident that this great advocate of, and pioneer in, bold and radical surgical operative procedures attempted whenever possible to reduce the requirement for such procedures, reserving them for situations in which no alternate choice appeared possible. In addition to published work there were other new paths he trod, about which he did not write. They ranged from surgery of the brain to that of aneurysms, transplantation of tissues, and a variety of imperative surgical procedures. There were also ingenious instruments which were devised and reported upon, and others of interest and usefulness not described in the literature.

Only in the latter portion of his career did Dr. Lilienthal apply his talents to thoracic surgery. One may assume that he was led to this field not only because of a lively interest in it but also because of the possibilities for pioneering work in the budding specialty. He was 53 years old in 1914, the year of his first lobectomy for chronic suppuration of the lung. When 57 years old, he was on his way overseas in World War I. Part of the time he headed a team for thoracic surgery in the forward area. His experiences encouraged him to continue with the problem of the surgical eradication of chronic pulmonary suppuration after the war. The classical paper on lobectomy for pulmonary suppuration was published in 1921. This work provided the stimulus for the surgical treatment of pulmonary suppuration by lobectomy or pneumonectomy as practiced at the present time, and the lasting significance of his contribution is thereby established. In the same year there also appeared the report of a successful esophagectomy for carcinoma through an extrapleural (posterior mediastinal) approach, the first successful mediastinal excision of an esophageal cancer. Other papers devoted to various aspects of thoracic surgery were included in Dr. Lilienthal's monograph on Thoracic Surgery published in 1925. The two volumes are replete with the personal experiences of the author in a great variety of intrathoracic lesions. Set forth clearly, interestingly, and provocatively, they are of such lasting quality that one chest surgeon could truly say in 1941 that "Thoracic Surgery published nearly twenty years ago is still a classic." This can be said with equal truth today.

Dr. Lilienthal in the midst of a busy professional career serving alike the famous and the unknown, the affluent and the poor, found time always to indulge his patients. Children or adults, they were his friends and he theirs. He brought his avocations to them—tales of nature lore of which he was a lifelong student, a snatch of a song sung in a rich tenor voice to an ailing child, or an entertaining sketch quickly drawn for another child. He found time to indulge these delightful avocations almost as if to bring them to his patients and his friends. He found time to attend medical meetings on the Continent as well as in our country, contributing stimulating ideas, delightfully spiced with wit and but rarely barbed. He found time to encourage and to stimulate the younger men who worked under him, as well as those of his own generation, and all those who came in contact with him—friends, confreres, patients—felt the combined impact of his personal charm and sincerity.

Howard Lilienthal was a great pioneer in the American surgical tradition. The contributions which he made to surgery are important and lasting. As lasting should be that inspiring spirit breathed by a happy fusion of knowledge, imagination, and intuition.

Harold Neuhof

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1946-1947

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